Jack Barry
242

REVIEW DRAFT

PILOT CONTROL PROJECT OF DYLOX

ON THE MODOC BUDWORM-1974

PROJECT REPORT

John R. Pierce
Project Leader

FOREST SERVICE
U. S. Department of Agriculture

630 SANSOME STREET
SAN FRANCISCO, 94111

(2)

CONTENTS

Acknowledgements

Forest Pest Control Staff entomologists Max Ollieu and Fay Shon performed and directed the critically important work in the field and laboratory respectively. Entomologist Ken Swain (FPC) did much of the planning work and handled formulation, calibration and application problems in the field. Forester Gary Fiddler (Modoc National Forest) skillfully handled a large variety of problems, duties and details. Reed Miller and Roy Blomstrom (FPC retired) volunteered arduous service in this field purely out of comradeship and interest in the project.

Numerous other cooperators and Forest Service employees, some named in the body of the report, worked effectively for long hours without complaints. In total, more than 100 people contributed significantly to the common effort.

REVIEW DRAFT

PILOT CONTROL PROJECT OF DYLOX ON THE MODOC BUDWORM

Project Report

INTRODUCTION

An epidemic of budworms was detected on the Modoc National Forest in 1973. The biological evaluation of the infestation indicated defoliation would intensify and enlarge in 1974. Considering that a registered pesticide was not available for use, recommendations were made to further evaluate the epidemic. A pilot control project of Zectran for the control of the Modoc budworm was proposed to be included in these evaluations. (Pierce et al 1974)

An Environmental Analysis Report (EAR) was completed and accepted on March 27, 1974. (Pierce, 1974). The EAR indicated that the pilot control project would not have a significant effect on the environment.

A plan for the project was completed on June 4, 1974. Coincidentally, notification was also received on June 4, that the sole manufacturer, Dow Chemical Company, would no longer produce Zectran. After considerable discussion, it was decided not to use Zectran in the pilot control project because even if adequate efficacy was demonstrated, Zectran would no longer be available.

After thorough discussion between staff members in several Regional Office Divisions, the Insecticide Evaluation Project (IEP) of the Pacific Southwest Forest and Range Experiment Station, and the California Department of Fish and Game, the insecticide Dylox was selected to replace Zectran. A pilot test plan for the use of Dylox was approved on June 17, 1974. (Swain et al 1974).

The common name of the insecticide tested is trichlorfon, which is Dimethyl (2,2,2-trichloro-1-hydrozyethyl) phosphonate $C_4 H_8 O_4 C_1P$), but hereafter will be referred to as Dylox. It is a broad-spectrum organo-phosphate which is registered for use on a wide variety of field crops, vegetables, seed crops and ornamentals. (Anon. 1971). Toxicity data is available (Andrews and Dugar, 1972), including:

(1) Acute mammalian toxicity (oral, dermal, inhalation, eye and skin irritation).

(2) Subacute mammalian toxicity.

(3) Neurotoxicity.

(4) Teratogenicity.

(5) Carcinogenicity.

(6) Metabolism.

The adverse side effects of Dylox in the forest were investigated during preparations for the Cooperative 1973 Gypsy Moth Suppression and Regulatory Program (Anon. 1973). The effects were reported on:

(1) Man and his food.

(2) Other Mammals.

(3) Birds.

(4) Non-target insects.

(5) Plants.

(6) Fish and other aquatic vertebrates.

(7) Aquatic invertebrates.

(8) Plankton.

(9) Non-living entities.

Dylox is non-persistent and relatively non-toxic to bees and wasps--some parasites of the Modoc budworm are wasps. Its satisfactory performance against the gypsy moth suggested that Dylox was a suitable pesticide for use in the forest. It has a longer residual life than Zectran and therefore might be equal or more effective. Based on studies in the East against the gypsy moth, Dylox has an effective life of about five days (Anon. 1973)

Laboratory screening of pesticides applied to budworms (Choristoneura spp.) larvae indicated also that Dylox would probably be effective in the field for budworm. IEP tested Dylox in the laboratory against the Modoc budworm and although it is less toxic to budworm than Zectran, it is much more toxic than DDT. (Robertson, 1974)

A revised EAR was prepared for the substitution of Dylox in the project and accepted on June 17, 1974. (Swain, 1974)

Realizing that budworm development and population estimates would be important in any pilot control project, preliminary field work commenced in mid-May. Subsequently, after the spray plan was completed and test areas selected, the Dylox pilot control project was carried out with spray applications occurring between June 26 and July 2, 1974.

To supplement previous work, environmental effects of Dylox were investigated during this 1974 pilot control project to elucidate those effects under northeastern California forest conditions. The studies carried out for this purpose were as follows:

Effects on (1) Water Contamination; (2) Aquatic and Terrestrial Insects; (3) Fish; (4) Wildlife; (5) Budworm Parasites; (6) Non-Target Terrestrial Arthropods, and (7) Residues in Foliage and Water.

OBJECTIVES

The pilot control project was conducted to investigate the efficacy and safety of aerially applying Dylox for the suppression of a Modoc budworm infestation. (The knowledge available from previous work, plus the results of this project, will be used to seek registration of Dylox for Modoc budworm control.)

EFFICACY INVESTIGATIONS (Methods)

TEST DESIGN

Three replications of three dosage rates were applied. (Williams, 1974) The three treatments were: zero, three-quarters, and one (1, 3/4, 1) pounds of Dylox per acre. Each of the three treatments was assigned three test plots. Two spray formulations were used so that the specified amount of Dylox (3/4 or 1 lb.) was contained in one gallon of spray mixture which was then applied at a calculated rate of one gallon per acre by helicopter. Nothing was applied to the plots assigned the zero dosage treatment. Therefore, the pilot test consisted of three plots treated with one pound, three plots treated with 3/4 pounds, and three plots left unsprayed, for a total of nine treatment plots. (Figurel

investigated during this 1974 pilot control project to elucidate those effects under northeastern California forest conditions. The studies carried out for this purpose were as follows.

Effects on (1) Water Contamination; (2) Aquatic and Terrestrial Insects; (3) Fish; (4) Wildlife; (5) Budworm Parasites; (6) Non-Target Terrestrial Arthropods, and (7) Residues in Foliage and Water.

OBJECTIVES

The pilot control project was conducted to investigate the efficacy and safety of aerially applying Dylox for the suppression of a Modoc budworm infestation. (The knowledge available from previous work, plus the results of this project, will be used to seek registration of Dylox for Modoc budworm control.)

Three replications of three dosage rates were applied. (Williams, 1974) The three treatments were: zero, three-quarter, and one (1, 3/4, 1) pounds of Dylox per acre. Each of the three treatments [illegible] assigned three test plots. Two spray formulations were used so that specified amount of Dylox (3/4 or 1 lb.) was contained in one gallon [illegible] a calculated rate of one [illegible] was applied to the plots assigned [illegible] pilot test consisted of [illegible] lots treated with 3/4 pounds.

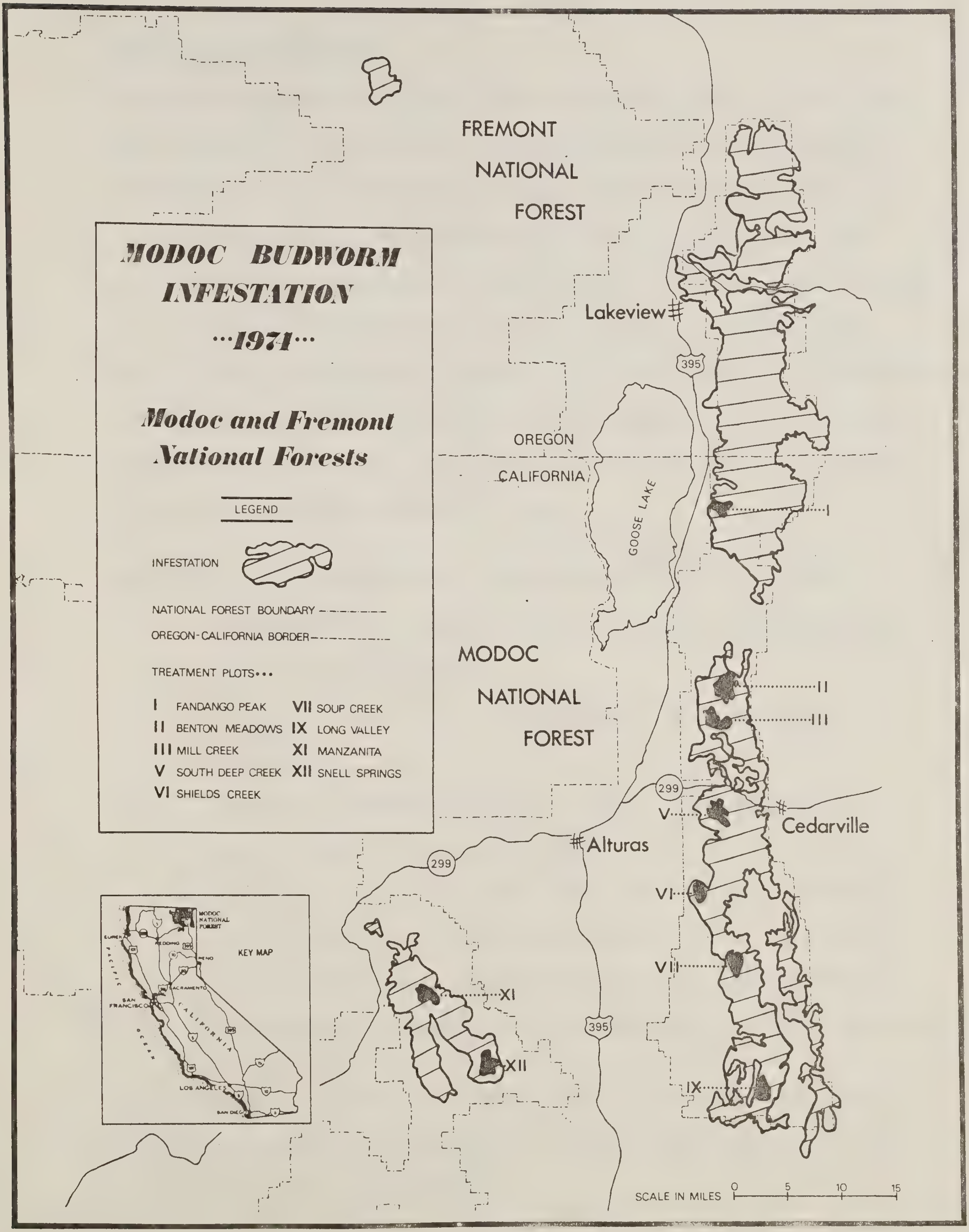


FIGURE 1. The Location of the Modoc Budworm Outbreak and Treatment Plots on the Modoc National Forest in California and the Fremont National Forest in Oregon, 1974.

TREATMENT PLOT SELECTION

Potential treatment plots were selected in early spring when the areas were inaccessible due to snow. Anticipating spray application dates in late June, and considering normal snow conditions of the area, it was realized that the plots would be accessible for only about one month for field work before spray application. This time table required that as much of the layout and survey work as possible be done with aerial survey, photographs, and maps. To allow flexibility to accommodate difficulties that might arise later, rendering one or more of the plots unsuitable for the test, twelve potential treatment plots were selected instead of the required number of nine.

Criteria used for selecting the treatment plots were as follows:

1. Infested area of approximately 1,000 acres, clearly defined by topographic features.
2. Stands of trees of suitable size and density to allow proper sampling.
3. Separation between blocks of at least 1.5 miles to guard against spray drift contamination.
4. Suitable terrain, i.e., the absence of prominent features that would interfere with spray application, such as very steep slopes, tall isolated trees or snags, etc.; and the presence of streams and meadows to use for the spray monitoring activities.

The areas were selected as treatment plots by delineation and careful study on maps and aerial photographs. These choices were then further verified by aerial reconnaissance.

[illegible] aerial treatment plots were selected in early spring when the areas were inaccessible due to snow. Anticipating spray application dates in late June, and considering normal snow conditions of the area, it was realized that the plots would be accessible for only about one month for field work before spray application. This time table required that as much of the layout and survey work as possible be done with aerial survey, photographs, and maps. To allow flexibility to accommodate difficulties that might arise later, rendering one or more of the plots unsuitable for the test, twelve potential treatment plots were selected instead of the required number of nine.

Criteria used for selecting the treatment plots were as follows:

1. Infested area of approximately 1,000 acres, clearly defined by topographic features.
2. Stands of trees of suitable size and density to allow proper sampling.
3. Separation between blocks of at least 1.5 miles to guard against spray drift contamination.
4. Suitable terrain, i.e., the absence of prominent features that [illegible] with spray application, such as very [illegible] [illegible]s or snags, etc.; and the presence [illegible] [illegible]se for the spray monitoring activities.

[illegible] [illegible]lots by delineation and careful [illegible]. These choices were t[illegible]

TREE CLUSTER LOCATIONS

The sampling scheme used to estimate budworm populations and follow budworm development over the large treatment plots was based on clusters of trees selected at ten separate locations within each plot.

The first step in selecting tree cluster locations was to delineate on aerial photographs of the treatment plots those stands judged to be too large or too dense to provide suitable sample trees. It was necessary that sample trees be well foliated trees, 30 to 40 feet tall, which were not screened from above by larger adjacent trees (Williams 1974). With unsuitable areas identified, ten locations were then chosen on the photographs in the remainder of plot area. These tentative cluster locations were then visited and finally selected in the field and numbered 1 through 10 for each treatment plot.

DEVELOPMENTAL SAMPLE TREES

Three trees were selected and marked A, B, and C at each cluster location for preliminary sampling. These trees became known as "developmental sample trees" and were repeatedly sampled prior to spray application to determine the insects present, their numbers, and development rate over time.

A development sample from a tree consisted of four 15-inch twigs--one twig from each quadrant of the mid-crown--clipped with a pole pruner equipped with a catchment net designed to capture all of the larvae present on the twig. (Photo 1) Developmental samples were taken to the laboratory and inspected under magnification to find, identify and record all larvae according to developmental stage (instar). (Photo 2)

CLUSTER L[illegible]

[illegible] sampling scheme used to estimate budworm [illegible]

budworm development over the larval [illegible]

[illegible] of trees selected [illegible]

[illegible] aerial photographs of the [illegible] plots [illegible]

be too large or too dense to [illegible] suitable sample trees.

[illegible] that sample trees [illegible] well

ta[illegible], which were not [illegible]

(Williams 1974). [illegible]

then chosen on the photographs [illegible]

tentative cluster locations were then visited and finally

[illegible] field and numbered 1 through 10 for each treatment [illegible]

DEVELOPMENTAL SAMPLE TREES

Three tre[illegible] were selected and marked A, B, and [illegible] cluster

[illegible]cation for preliminary sampling. These trees [illegible]

[illegible]opment[illegible] sample trees" and were repeatedly sampled [illegible]

[illegible] to determine the insects present, their numbers, [illegible]

[illegible]opment rate over time.

[illegible]ample [illegible] tree consisted of four 15-inch [illegible]

[illegible] of the mid crown [illegible] with [illegible]

[illegible] net designed to capture all of the larvae

(Photo 1). Developmental samples were taken [illegible]

[illegible] magnification [illegible] identify [illegible]

[illegible]opment[illegible] instar).

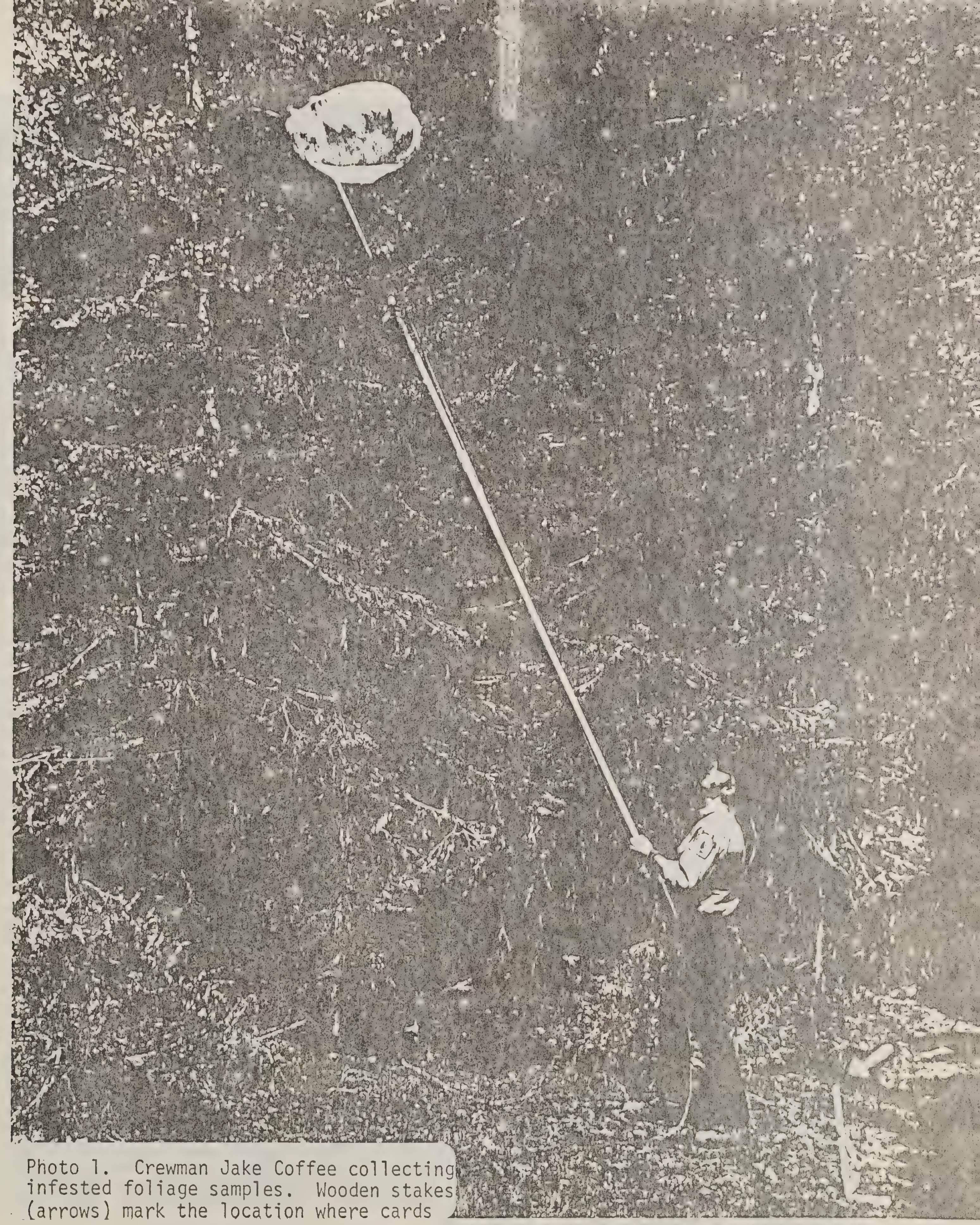


Photo 1. Crewman Jake Coffee collecting infested foliage samples. Wooden stakes (arrows) mark the location where cards and aluminum plates will be displayed to monitor the spray application.

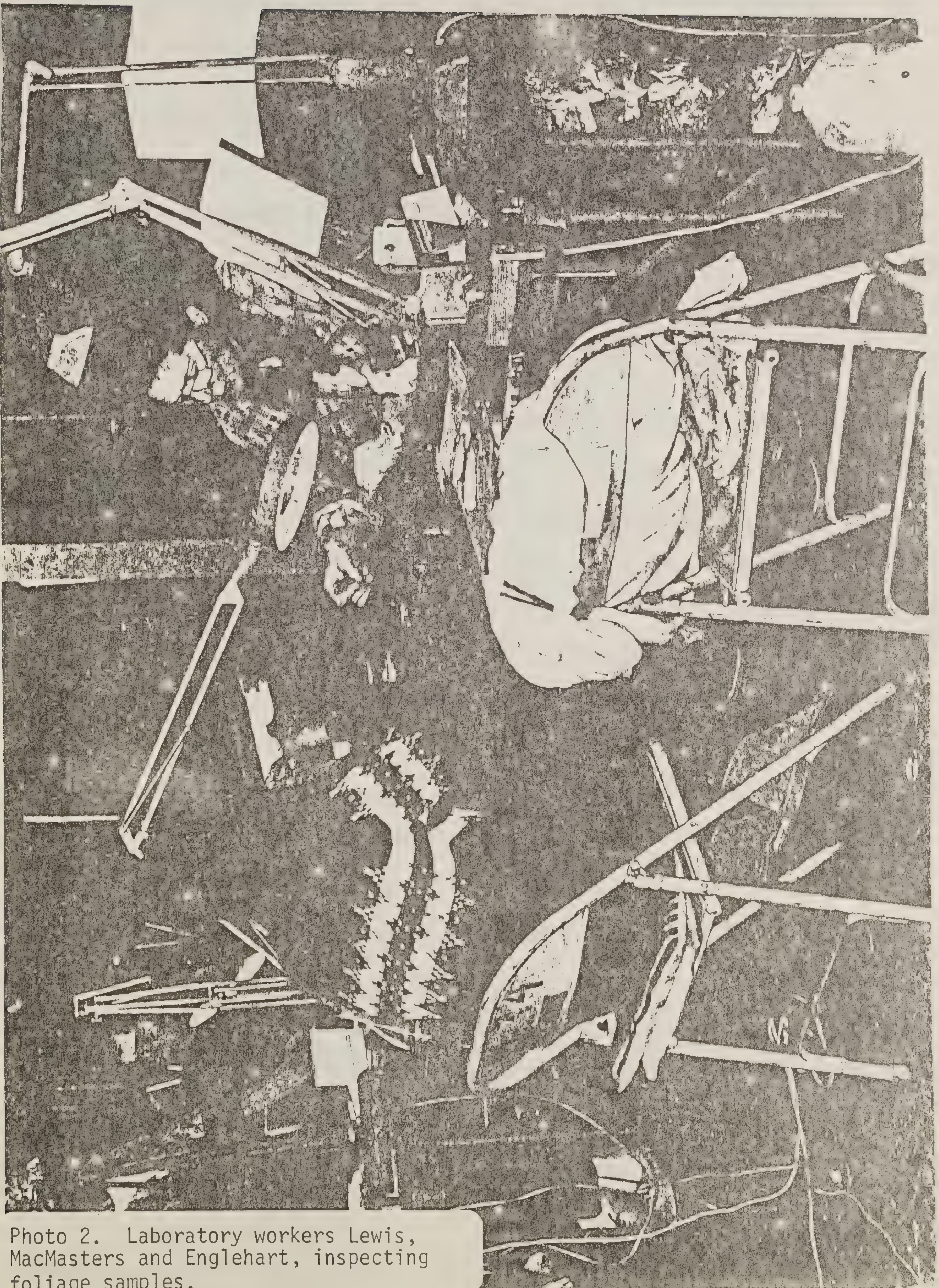


Photo 2. Laboratory workers Lewis, MacMasters and Englehart, inspecting foliage samples.

Laboratory workers were supervised by a qualified entomologist and, in addition, were provided training by a qualified taxonomist.

SPRAY FORMULATION

The spray solutions were formulated from the insecticide Dylox 1.5, manufactured by Chemagro Corporation containing 1.5 pounds of Dylox per gallon, and raw unmanufactured crop oil. To provide visible spray deposits on cards and plates used to monitor spray application, Rhodamine B extra base dye mixed in oleic acid was added.*

Two large tank trucks with hydraulic drive paddle agitators were provided by the spray contractor for spray mixing and transportation. (Photo 3) Two formulations were prepared in the following manner:

1. Check the mixing tank and hoses to see that they were clean and contain no sediment or other solvents.
2. Place the Dylox in the mixing tank.
3. Add the pre-mixed solution of Rhodamine B extra base dye in oleic acid.
4. Mix thoroughly for 30 minutes.
5. Add crop oil.
6. Mix thoroughly for 30 minutes.
7. Mix again for 5 minutes before loading any of the formulation into the helicopter.

---

* Dye solution was formulated separately by adding 17 lbs. of Rhodamine B extra base dye to 51 gallons of oleic acid and mixing thoroughly.

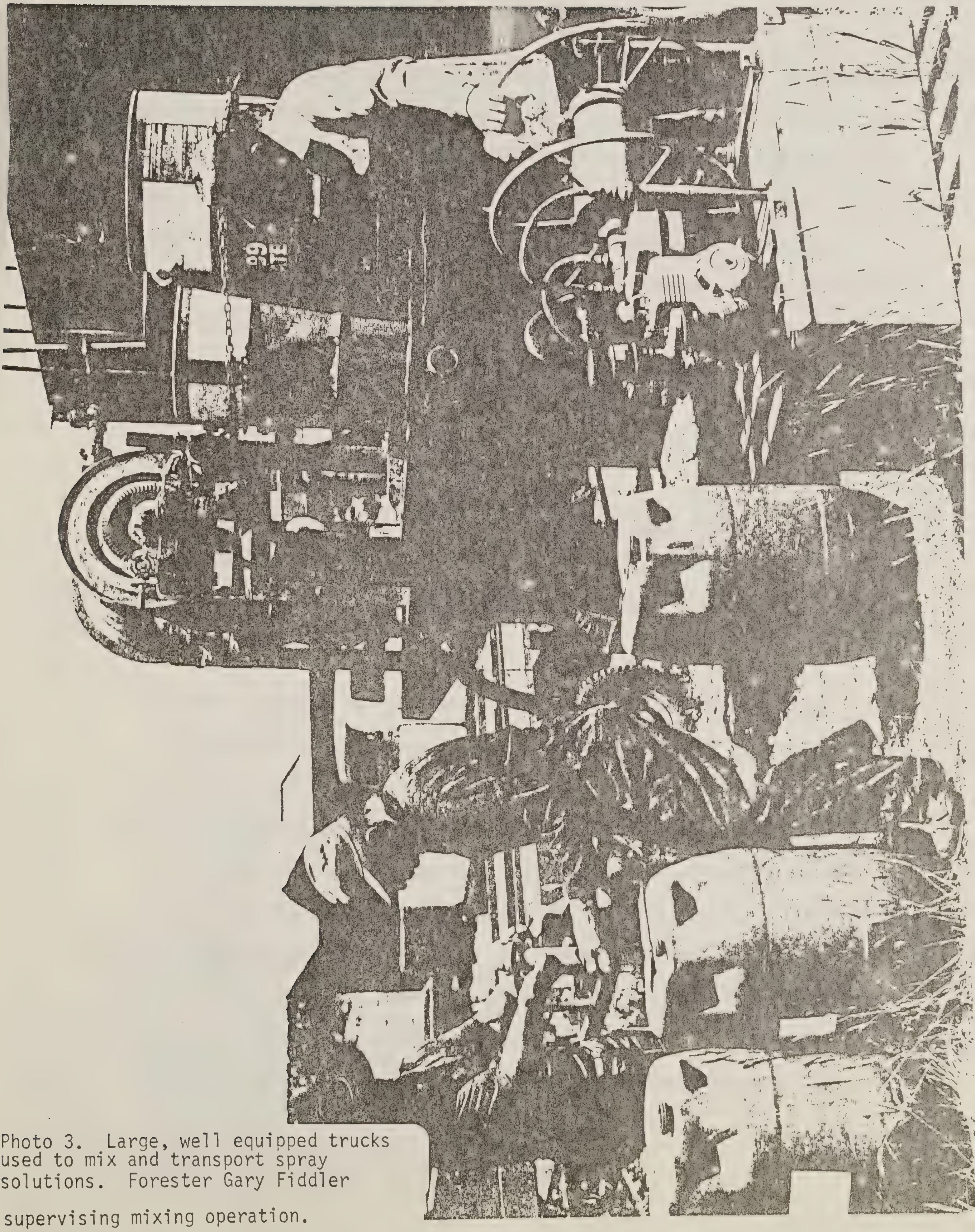


Photo 3. Large, well equipped trucks used to mix and transport spray solutions. Forester Gary Fiddler supervising mixing operation.

The spray solution which was to contain 0.75 pounds of Dylox per gallon was mixed entirely in one tank truck while the other tank truck was used to mix the 1.0 pound per gallon formulation. The receipt used to mix these formulation was 1 gallon of Dylox 1.5 to 1 gallon of crop oil for the 0.75 pounds per gallon formulation and 2 gallons of Dylox 1.5 to 1 gallon of crop oil for the 1.0 pound per gallon formulation. One quart of the dye mixture was added for each 10 gallons of spray which was calculated to provide a 0.1% dye content in the finished solution.

SPRAY EQUIPMENT CALIBRATION

Western Helicopter Services Inc. of Newburg, Oregon supplied two Bell 47G spray helicopters with qualified pilots. One helicopter was equipped with a positive displacement spray pump and the other one had a centrifugal pump.

The spray apparatus of each helicopter was calibrated by a ground procedure and an aerial test. On the ground the volume of spray pumped through several of the spray nozzles during a timed interval was collected and measured in order to calculate the number of nozzles required to provide the specified application rate of one gallon per acre. (Photo 4 & 5). To achieve the desired droplet size of 120 microns, 80015 Tee Jet nozzles were used. The aerial test consisted of flying a simulated spray run over a long strip of paper and a line of spray cards to varify swath width and droplet size. (Photo 6). The important calibration parameters determined were as follows:

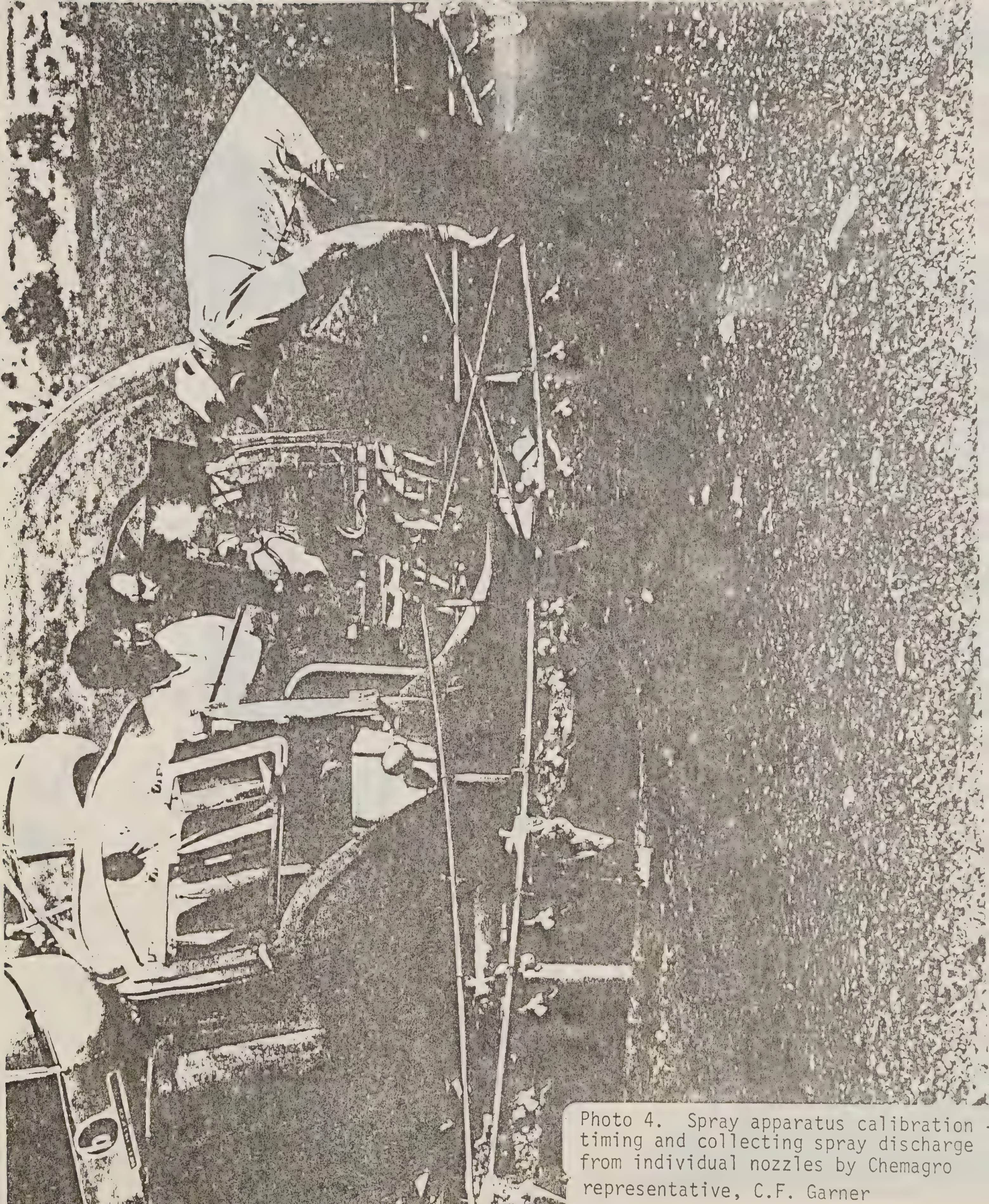


Photo 4. Spray apparatus calibration - timing and collecting spray discharge from individual nozzles by Chemagro representative, C.F. Garner

Photo 5. Spray apparatus calibration--measuring spray solution discharged during a timed interval.

Photo 6. Card and paper tape used to check droplet size and spray swath width.

1. 40 foot boom
2. 50 mph
3. 80 foot swath width
4. 55 PSI pump pressure
5. 1 helicopter with centrifugal pump and 100 mesh in-line strainer.

   1 helicopter with positive displacement pump and 100 mesh in-line strainer.
6. Forty-seven 80015 Tee Jet nozzles with 100 mesh screens.
7. Nozzles were placed 45 into the wind

During spray application on the first plot treated, it was apparent that the physical properties of Dylox spray tended to plug up the screens and nozzles. The spray apparatus equipped with the centrifugal pump was unable to operate effectively for any length of time and the apparatus equipped with the positive displacement pump was marginally operative. To eliminate this plugging up problem, the next larger size nozzles and strainers were used and the spray systems recalibrated. The rest of the spray application was carried out with 80002 Tee Jet nozzles and 50 mesh in-line strainers and the number reduced to thirty-four nozzles also with 50 mesh screens.

SPRAY APPLICATION

Treatment plots were approximately 1000 acres in size and located in rugged terrain which created difficult problems of orientation for the application pilots. To enable complete treatment of a plot during the brief period of favorable weather early each morning, both spray helicopters worked in the same plot. An aerial observer in a third helicopter also was always in the air during spray application.

33 foot boom

50 mph

3. 90 foot swath width

4. 55 PSI pump pressure

5. 1 helicopter with centrifugal pump and 100 mesh in-line [illegible]

1 helicopter with positive displacement pump and 100 mesh in-line strainer.

6. Forty-seven 80015 Tee Jet nozzles with 100 mesh screens.

7. Nozzles were placed 45 into the wind

During spray application on the first plot treated, it was apparent that the physical properties of Dylox spray tended to plug up the screens and nozzles. The spray apparatus equipped with the centrifugal pump was unable to operate effectively for any length of time and the apparatus equipped with the positive displacement pump was marginally operative. To elim[illegible] is plugging up problem, the next larger size nozzles and strainer [illegible]sed and the spray systems recalibrated. The rest of the spray [illegible] out with 80002 Tee Jet nozzles reduced to thirty[illegible]

Treatment plot boundaries were purposely layed out along easily recognized terrain features such as roads and ridges. A small number of markers made of different colored ribbon (carrousel markers) (Photo 7) were placed in the top of trees in highly visible locations and lime ground markings (Photo 8) in opening along plot boundaries were used as location and orientation markers for spray pilots and the aerial observers. The aerial observer and each spray pilot was given an aerial photograph (scale 8 inch per mile) showing the spray boundary and the location and color of the carrousel markers. The location of the heliport selected for each spray plot was also shown on the aerial photograph.

With these aids in hand, the spray contractor was responsible for transporting, properly agitating, loading and applying the correct amount of spray solution evenly to the entire plot area. (Photo 9). Spray application was monitored on each plot by Forest Service crews to evaluate this performance.

PRE AND POST-SPRAY SAMPLE TREES

Data accumulated from the developmental sample trees were analysed by methods suggested by Bousfield (Bousfield, 1974), to determine pre- and post-spray sample parameters needed to indicate treatment efficacy. This determination was that, based on the variability of the budworm population, four twigs from eight trees per cluster would be needed.

Eight spray sample trees were then selected at each of the ten cluster locations per plot and numbered 1 through 8. An open area on two sides of the crown of each spray sample tree was also identified by wooden stakes (Photo 1) for the location of cards and plates used to assess the

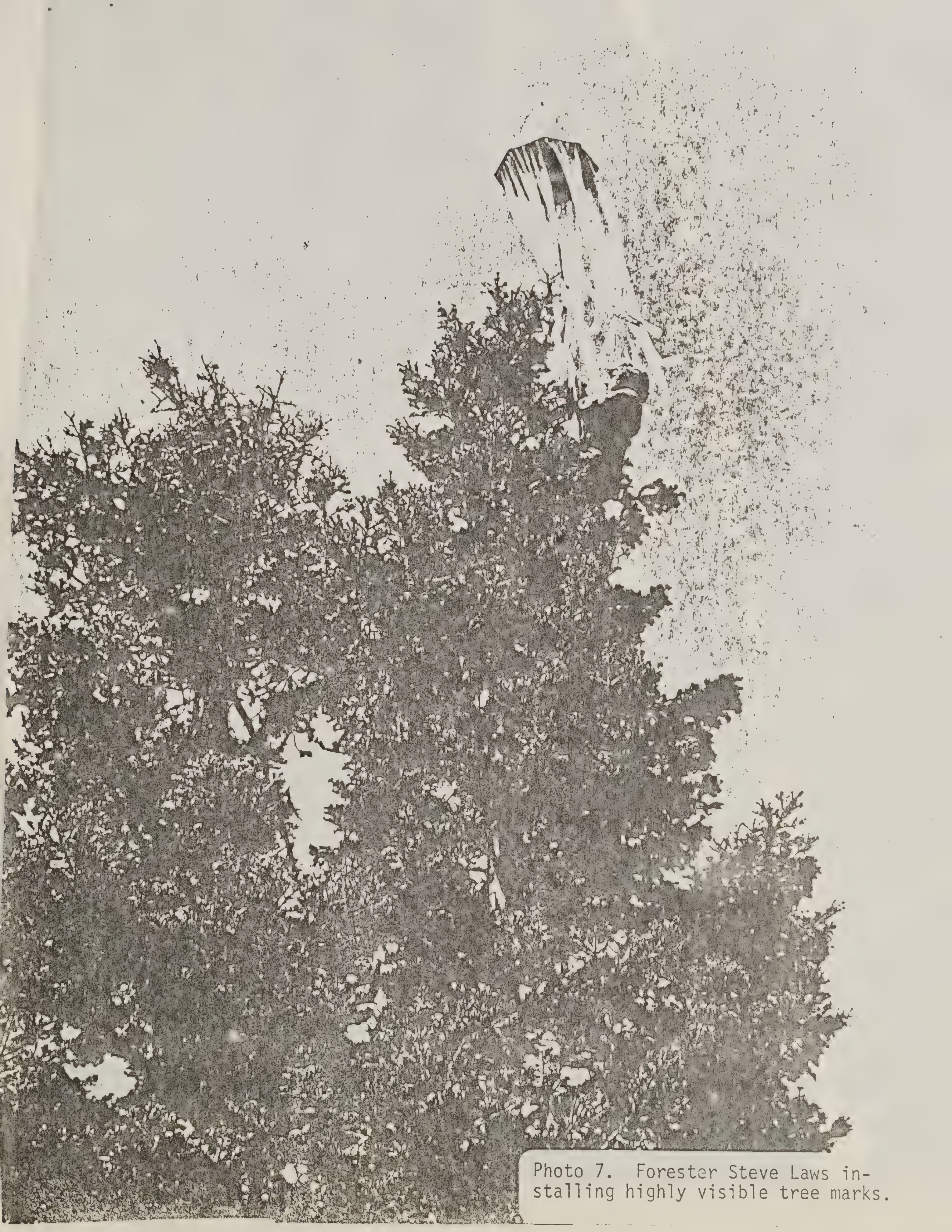


Photo 7. Forester Steve Laws installing highly visible tree marks.

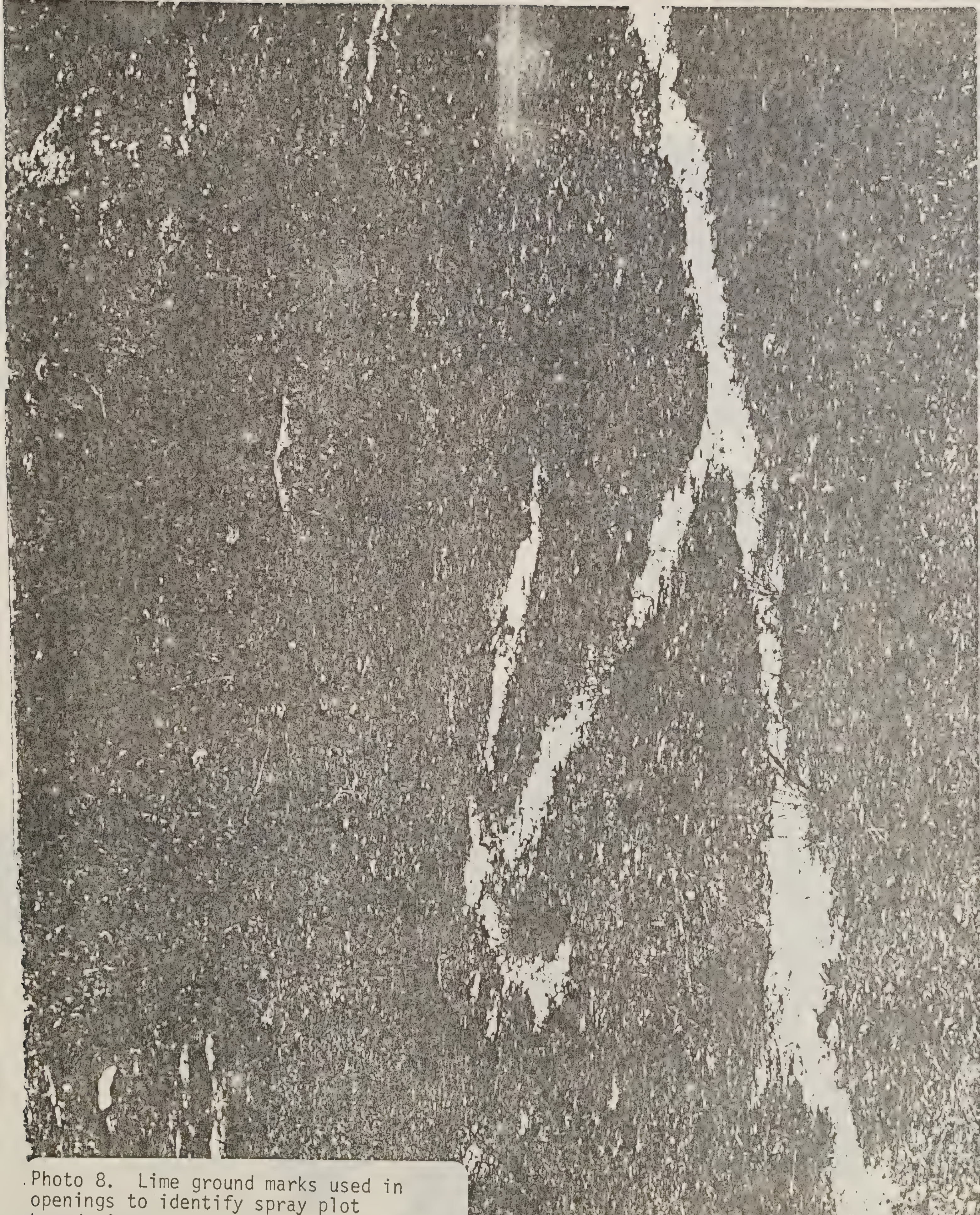


Photo 8. Lime ground marks used in openings to identify spray plot boundaries.

Photo 9. Helicopter application of spray solution by Western Helicopter Services, Inc. of Newburg, Oregon.

spray deposited at each spray sample tree location.

One day prior to the expected spray application on a plot, the pre-spray sample was collected by field crews. Four twigs per sample tree were taken with pole pruners and processed in the laboratory in the manner described for development sample trees. Six days and again sixteen days after spray application, the spray sample trees were sampled for the post-spray measurement of budworm populations. A double sample--eight twigs per tree--was collected for the post-spray determinations to guard against the possibility that budworm numbers might be reduced to levels too low to be adequately estimated by the normal sample.

DROP CLOTHS

A drop cloth experiment, conducted by PSW, called for the deployment of a drop cloth under the forest canopy near the center of each cluster of trees used in the pilot project. Essentially, a drop cloth was a large funnel made of plastic sheeting leading to a jar partially filled with alcohol and sampled about one-square-yard of area under the tree crowns. (Photo 10). Material falling from the tree crowns (Photo 11) into the funnel provided information on: (1) immediate evidence of spray effects; (2) organisms affected by the spray; (3) frass production in sprayed and unsprayed plots; and, (4) the time interval the spray continued to kill insects.

On the sprayed plots the material caught in the drop cloth jars was collected on the second, fourth, and sixth days after spraying. On the unsprayed plots, a cummulative 6 day sample was obtained.

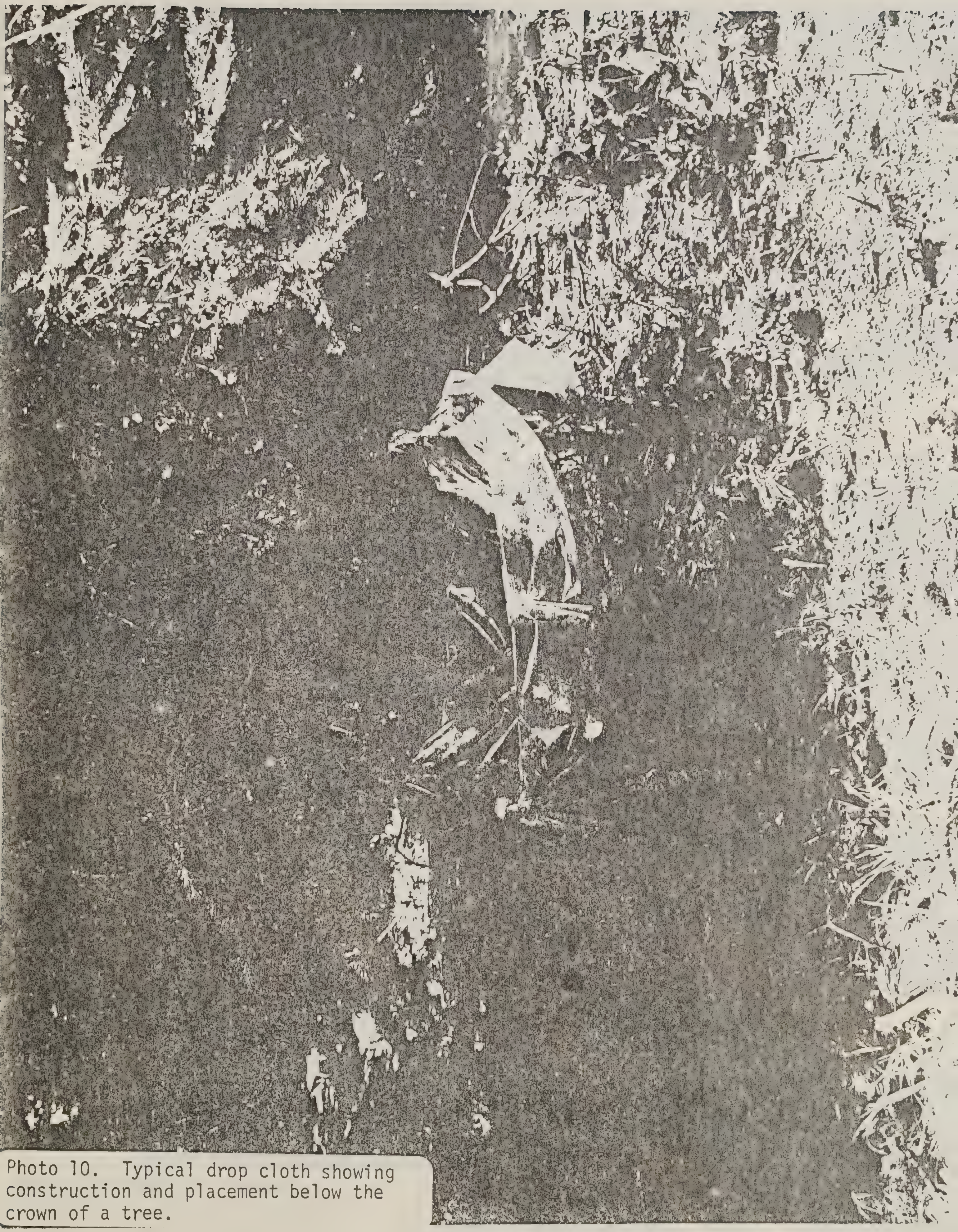


Photo 10. Typical drop cloth showing construction and placement below the crown of a tree.

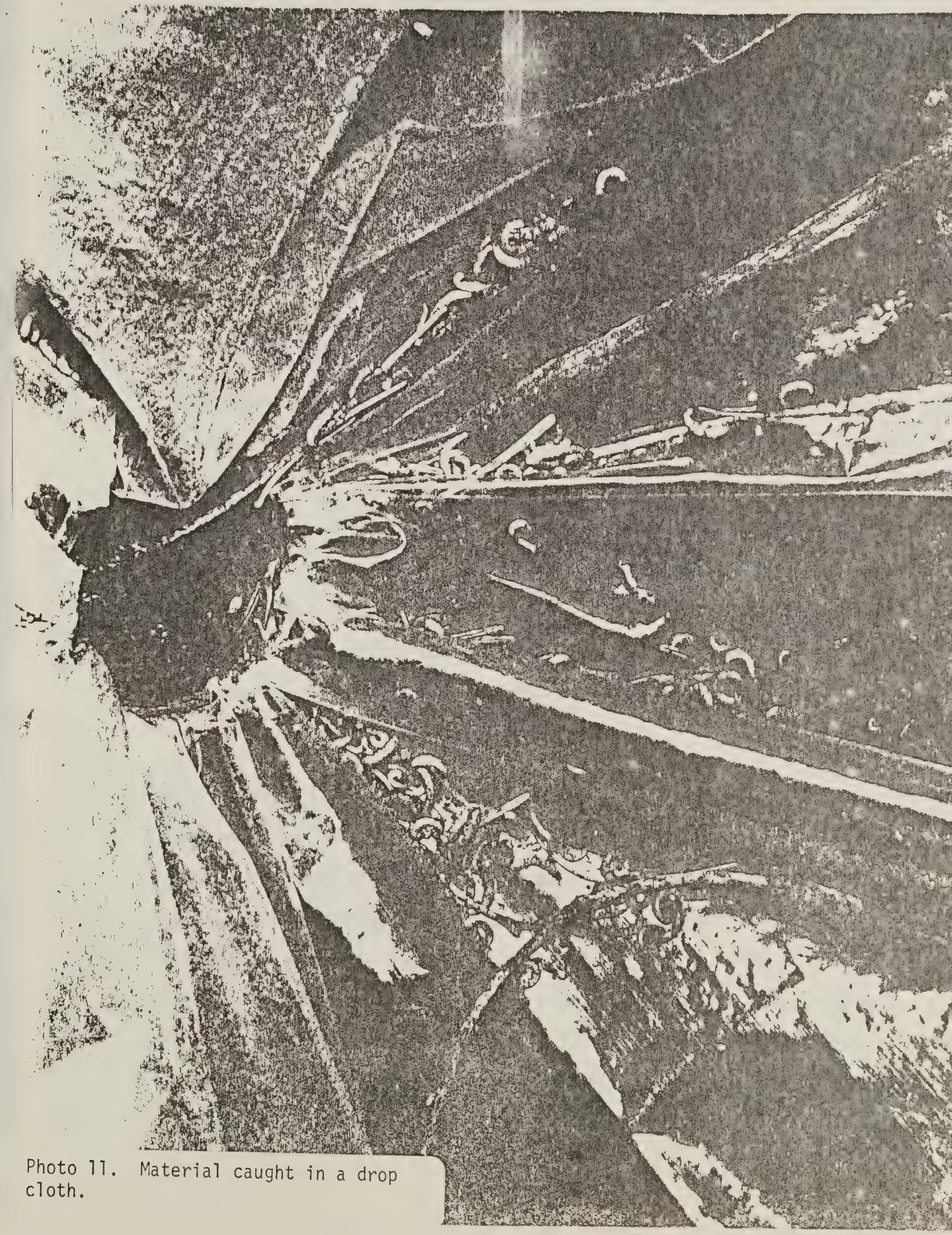


Photo 11. Material caught in a drop cloth.

The drop cloth samples were brought to the PSW Laboratory for processing. The insects and frass were separated from the needles and twigs. The frass was dried and weighed and selected species of insects were counted. The remaining insects and spiders were saved for the non-target terrestrial arthropod monitoring effort.

The insects from the crop cloth samples which were counted for this evaluation were the Modoc budworm, spruce coneworm, elaterid beetles, scarab beetles, ants, and flies. The number of insects caught in the unsprayed plots was taken to be the normal rate at which these particular insects fall from the trees. The larger numbers of insects caught in the drop cloths in the sprayed plots are presumed to reflect the knock down effect of the spray. When the numbers of a particular insect caught during a sample period is near or lower than the average number of that insect caught in the unsprayed plots it is believed to indicate that the spray is no longer affecting that species or that nearly all the available individuals have been killed.

SPRAY CARDS AND PLATES

Immediately prior to spraying, field crews deployed special paper (Kromekote) cards and aluminum plates near each spray sample tree at the location marked by wooden stakes. A pair, consisting of a card and plate, were displayed horizontally in wire card holders (Photo 12) to the open sky on two sides of the tree crown to intercept spray droplets falling from the helicopter. The spray contained a fluorescent dye, which collected on the cards and plates, for the purpose of estimating the spray dosage applied.

The drop cloth samples were brought to the FSM laboratory for processing. The insects and frass were separated from the needles and twigs. The frass was dried and weighed and selected species of insects were counted. The remaining insects and spiders were saved for the non-target (terrestrial) arthropod monitoring effort.

The in[illegible] from the drop cloth samples, which were counted for this [illegible] were the Modoc budworm, spruce coneworm, sisterid beetles, scarab beetles, ants, and flies. The number of insects caught in the unsprayed plots was taken to be the normal rate at which these particular [illegible] fall from the trees. The [illegible] numbers of insects caught in the drop cloths in the [illegible] plots are presumed to reflect the knock down effect of the spray. [illegible] the numbers of a particular insect [illegible] [illegible] higher or lower than the average number [illegible] [illegible] plots it is believed to indicate [illegible] that species or that nearly all [illegible] killed.

[illegible] crews deployed special [illegible] [illegible] near each spray sample tree at [illegible]. A pair, consisting of a card and [illegible] wire card holders (Photo 12) to the tree crown to intercept spray droplets [illegible] contained a fluorescent dye.

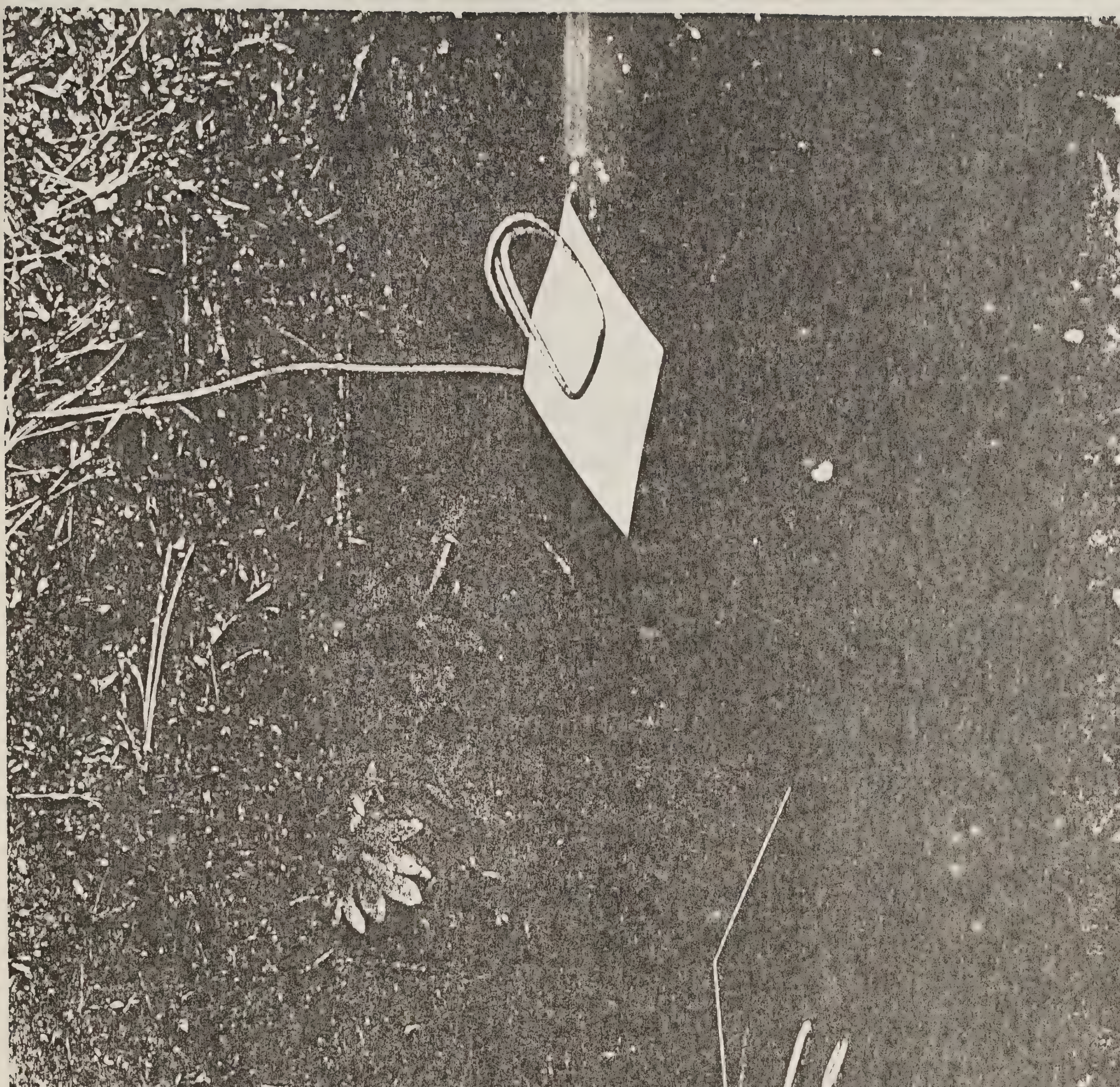


Photo 12. One pair of spray deposit samplers - Kromekote card (L) and aluminum plate (R).

Spray cards and plates were deployed (Photo 13) immediately before spraying--that is about 0400 in the morning--and collected about one hour after spraying. This timing was considered important since moisture might damage the cards and sunlight might bleach away part of the dye if the cards and plates were exposed too long.

The aluminum plates were processed at IEP by washing the dye from the plates and determining spray dosage with fluorometric methods. The spray cards were processed by an Imanco Image Analyser located at U.C. Davis.

ESTIMATES OF FOLIAGE CONSERVATION

Spray applications for budworm control are made against the mature larvae because that stage is the most exposed to contact by spray deposits. Unfortunately, serious defoliation of the trees usually has occurred by the time the spray is applied. To determine if the 1974 pilot control project was effective in saving any foliage on the treated trees, both field and laboratory estimates of defoliation were made during the pre- and post-spray sampling work on treated and untreated plots.

In the field, an ocular estimate of defoliation was made for each tree when the pre-and post-spray samples were collected. The estimator divided the tree crown into six horizontal segments and separately scored the estimated loss of new needles and of old needles in each segment. A score of 0 represented no visible defoliation, I indicated legs than 50%, 2 indicated 50-90%, and 3 more than 90% loss of needles.

spray--that is about 0800 in the morning--and left for [illegible] an hour after spraying. This timing was considered important as moisture might damage the cards and [illegible] light might destroy the dye if the cards and plates were exposed too l[illegible]

The aluminum plates were processed at IBL by washing [illegible] plates [illegible] determining spray dosage with fluorometric [illegible] Spray cards were processed by an Imanco Image Analyzer [illegible] U.C. Davis.

ESTIMATE OF FOLIAGE CONSERVATION

Spray applications for budworm control are made against the mature larvae because that stage is the most exposed to contact by spray droplets. Unfortunately, serious defoliation of the trees usually has occurred by the time the spray is applied. To determine if the 1976 [illegible] protection is effective in saving any foliage on the treated [illegible] laboratory estimates of defoliation were made during the [illegible] y sampling work on treated and untreated plots.

[illegible] ar estimate of defoliation was made for each tree [illegible] post-spray samples were collected. The estimator [illegible] crown into six horizontal segments and separately [illegible] ted loss of [illegible] needles and of old needles in each [illegible] ed no visible defoliation, 1 indicated [illegible] %, and [illegible] more than 90% loss of needles.

Photo 13. Forester Bud Veirs labeling and installing cards and plates prior to spray application.

In the laboratory, the number of significantly defoliated shoots on each sample branch was recorded as the samples were processed. Damage was rated on a scale of 0 to 3 by the use of the formulae:

$$\frac{\text{Number of damaged shoots}}{\text{Total number of shoots}} \times 3$$

GROWTH-LOSS INVESTIGATIONS

PSW initiated field work to investigate the growth loss suffered by trees due to defoliation.

Since total growth suppression is not immediately expressed in trees suffering current defoliation, this initial work was conducted in areas known to have been also infested by budworms in earlier year.* This provided the opportunity to use methods of investigation explained elsewhere (Graham. 1963) and accumulate some historic perspective for interpreting current effects. The main part of the investigation will be carried out after the effects of the current outbreak are registered in the growth patterns of the trees.

The evaluation of growth loss involves the analysis of both internode longitudinal growth and radial increment. Sample trees were felled to measure internodal distances. Disks were cut from three locations of the bole and the annual increments measured in the laboratory. Both host and non-host trees were sampled.

---

* Budworms are known to be indigenous pests of white fir and lodgepole pine in the Warner Mountains of Modoc County. The last noticeable infestation began during the mid-1940's and persisted through 1963 (California Forest Pest Control Action Council, 1949-1964); during this 15-year period, damage fluctuated at an innocuous level for several years. By 1959 the infestation had enlarged to approximately 2800 acres. In 1960 top killing was noted, and in 1963 heavy defoliation and top killing occurred on several thousand acres; however, the infestation collapsed following the 1963 generation and, until 1973, budworm activity was detected at very low levels only.

WEATHER FORECASTING AND MONITORING

Weather conditions were recognized as a critical factor for the successful aerial application of the insecticide and were an element of consideration incorporated in the aerial application contract.

A full time weather consultant and mobile forecasting laboratory (Photo 14) was assigned to the project, by the U.S. Weather Bureau, to provide the required expert advise in the application phase of the work. The critical factors to be managed with this advise were (1) to insure that the spray applications were made within the weather condition limits specified in the contract and (2) avoid pre-dawn transportation of large numbers of people and equipment to the application site without assurance that some productive work could be done.

The plan of action was for the weatherman to formulate a prediction, in late afternoon, of weather conditions on the application site at dawn the following morning. The mobile unit was outfitted with radio and telecopier equipment and observational tools to accomplish this forecasting. (Photo 15 & 16). Spray application was scheduled on the basis of this late afternoon prediction. The following morning the weatherman and one assistant monitored weather conditions, such as wind speed, temperature and humidity, on the treatment plot. He then advised the project leader (Photo 17) regarding existing weather conditions at the application site and the project leader continued or curtailed spray application according to these on site and continuous observations. Ground observations were also supplemented by aerial observation of the colored spray cloud emitted by the spray helicopters.

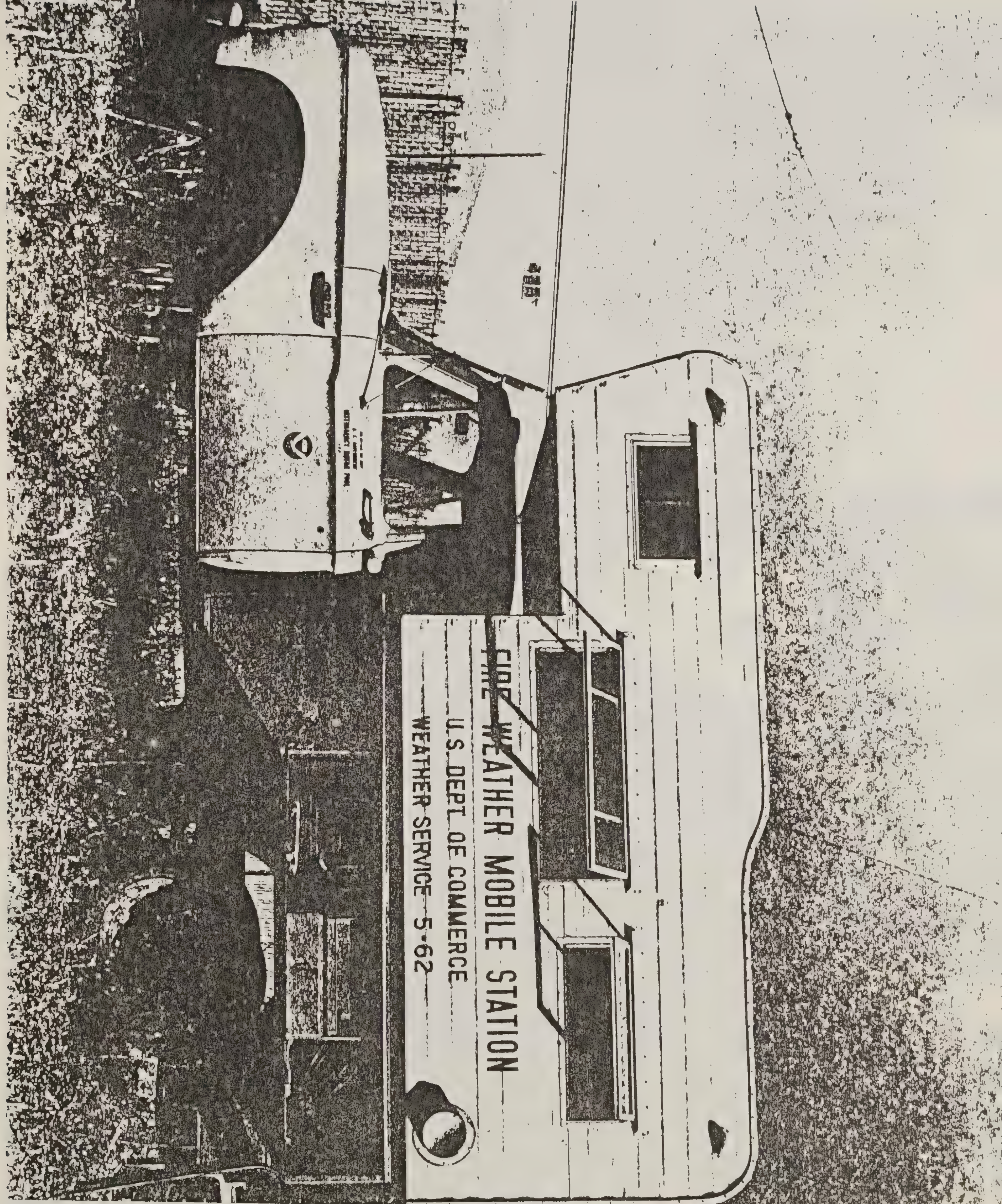


Photo 14. Mobile weather station assigned to the project.


U.S. DEPT OF COMMERCE
WEATHER MOBILE STATION

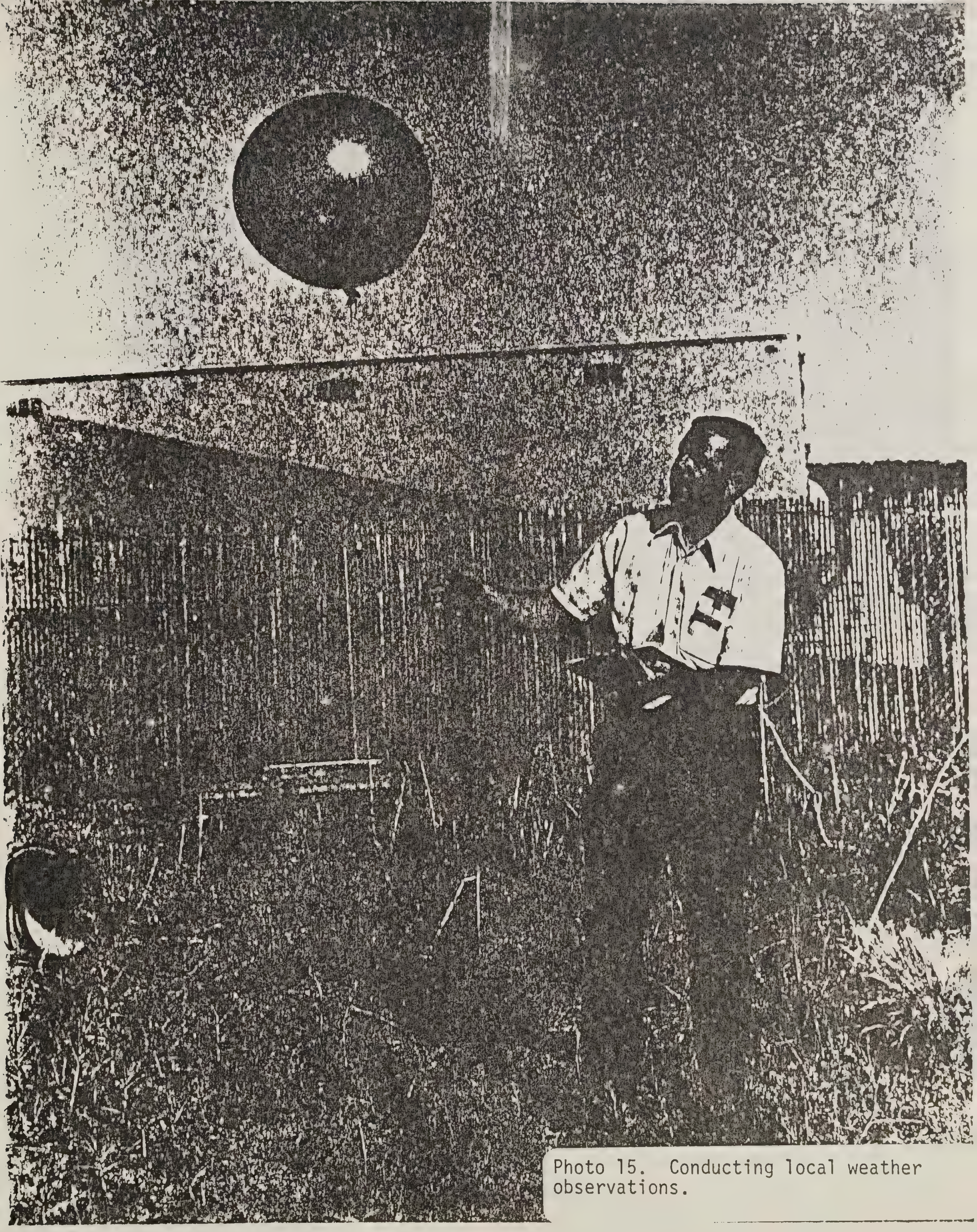


Photo 15. Conducting local weather observations.

Photo 16. Forecaster Bob Lamb checks latest facsimile weather charts.

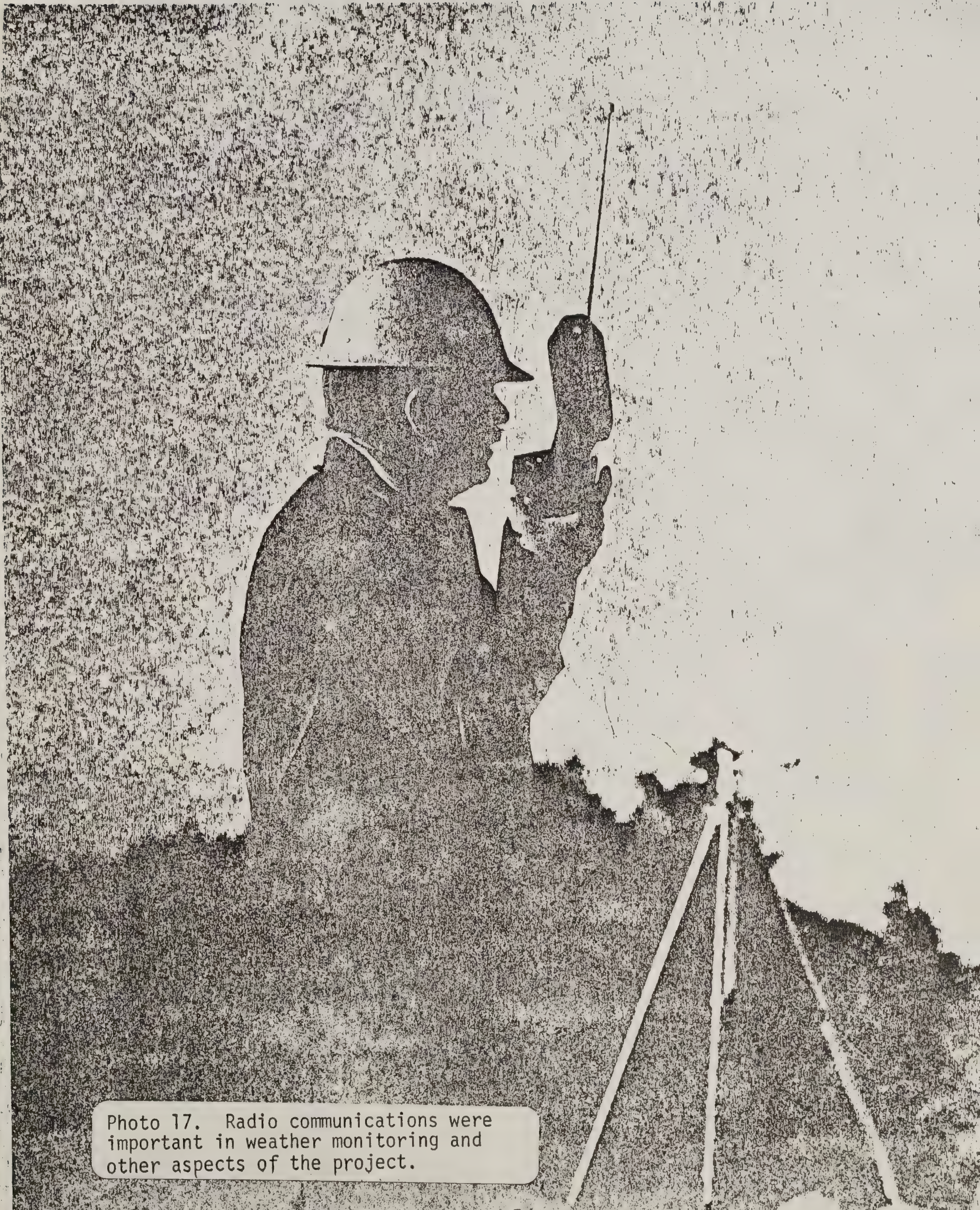


Photo 17. Radio communications were important in weather monitoring and other aspects of the project.

SAFETY MONITORING (Methods)

Several components of the forest environment were monitored to indicate the degree of environmental safety with which Dylox could be used under northeastern California conditions.

WATER CONTAMINATION

A large water sampling project was carried out to: (1) provide water quality data for registration of Dylox for use on Modoc budworm; (2) measure the effectiveness of 100-foot wide buffer strips adjacent to perennial streams; (3) qualify Dylox content of streams over time for two unprotected (not buffer) intermittent streams; (4) correlate Dylox content with Rhodamine B dye content, and (5) determine Dylox content of the water for interpretation of the fish and aquatic insect monitoring work.

To accomplish these objectives, two perennial streams and two intermittent streams were selected--one of each type of stream in a 3/4 pound treatment area and one each in a 1.0 pound treatment area. The applicator pilots were instructed to leave a 100-foot-wide unsprayed buffer strip along the selected perennial stream. They were not instructed to leave a buffer strip along the selected intermittent streams which were well-flowing streams at the time of spray application.

Water samples were collected from the selected streams (Photo 18) one day prior to spray, twice during the day of spraying, and one sample each day for 5 days after spraying. Samples were handled in a manner to protect the Dylox and Rhodamine dye content until analysed. The amount of spray contamination and determined by both laboratory analysis for Dylox content and analysis for Rhodamine B dye content by fluorometric procedures.

Photo 18. Jan Ostby and Richard Hanes Modoc National Forest scientists, collecting water samples.

AQUATIC AND TERRESTRIAL INSECTS - The effects of the spray treatment on aquatic and terrestrial insects in stream zones were investigated. Benthic and drift sample collections of insects were made above, within, and below the treated zone in both unsprayed (buffered) and sprayed (unbuffered) streams. Sampling was done one day prior to treatment, immediately after treatment, one day and one week after treatment. Live traps containing three key aquatic insect orders were also deployed at the sampling stations and inspected for insect mortality 48 hours after treatment.

FISH - Observations of fish behavior and collection of fish for residue analysis were made in one stream for each of the three treatments--zero, 3/4, and 1 pound Dylox per acre. Sampling stations were established at two locations within the treatment areas and at one location one-half mile below the treated area (only two stations established in the zero treatment area).

One sample of fish, for residue analysis, was taken one to two weeks prior to treatment. Additional fish were collected 24 hours, 48 hours, and one week after treatment.

Block nets, and live cars with approximately 10 fish each, were maintained at each station. (Photo 19). Observations of fish behavior in the live cars were recorded 24 hours prior, immediately prior, and immediately after, 24 hours after, and one week after spray application. Any dead fish discovered in the block nets or live cars were collected for residue analysis.

Photo 19. California Dept. of Fish and Game personnel installing live cav.

WILDLIFE - A species abundance index survey was made to detect any adverse effects of the treatment on wildlife.

Six 2-hour transects were made in a spray treated area, consisting of 4 stations in each transect, approximately ½ mile in length. At each station the (1) species present, (2) number of animals in each species (sex and age), and (3) observations of behavior were recorded. The transects were made prior to treatment, 48 hours after treatment, and one week after treatment. Any species displaying unusual behavior or dead animals were collected and sent to a laboratory for examination and analysis.

Budworm Parasites - Rearing studies were conducted to detect effects of the Dylox treatment on budworm parasites. Budworm larvae collected from 20% of the sampled trees before and after spraying and from sprayed and unsprayed plots were reared through to the adult stage or until mature parasites emerged. (Photo 20). Emerged parasites were recovered and identified.

This work provided information about the rate of parasitism and the parasites active in (1) treated and untreated areas, and (2) treated areas before and after spraying.

Non-Target Terrestrial Arthropods - A large species and individual abundance survey was made to monitor the effects of Dylox treatment on arthropod inhabitance of the forest. Samples were collected from trees and forest litter prior to treatment and six and sixteen days after treatment. All clusters and trees on all treatment plots were included in the survey.

[illegible]

and analysis.

[illegible]

Dylox treatment [illegible]

30% of the sampled tree [illegible]

unsprayed plots were treated [illegible]

parasites emerged. (Photo 21). Exposed [illegible]

identified.

[illegible]

[illegible] treated and [illegible]

[illegible] emergence after spraying.

[illegible]

[illegible] Dylox [illegible]

Forest. Samples were collected from [illegible]

[illegible] to treatment and six and [illegible] days after

[illegible] and trees on all treatment plots were [illegible]

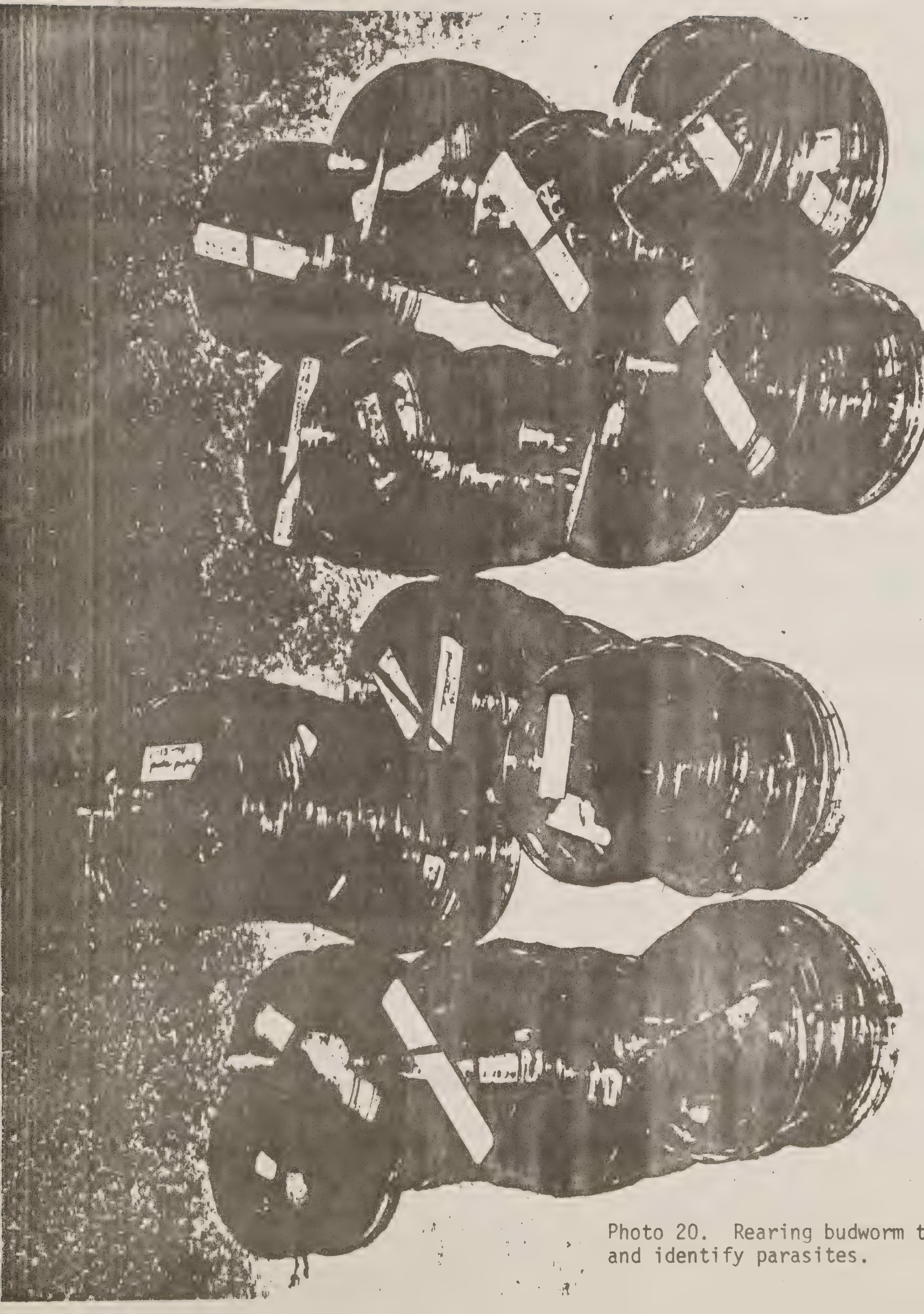


Photo 20. Rearing budworm to recover and identify parasites.

Tree samples consisted of a whole branch taken from eye level of the tree. The samplers quickly enclosed the branch in a large plastic bag to capture all of the insects, spiders, etc., present on the branch, sealed the bag around the branch base with tape, and removed the bagged branch to the laboratory. (Photo 21). Litter samples consisted of ½ cubic foot of material, collected by hand, and sealed in a plastic bag. (Photo 22).

In the laboratory, the organisms were separated from the branches and litter and stored in alcohol vials. (Photo 23). Later, these bulk samples were sorted by Order and Family and experienced taxonomists then counted and identified the organisms by genus and species, when known.

Residue Analysis - A great deal of data has been collected from eastern forests on residues of Dylox applied at the rate of 1 pound per acre. Some additional residue analysis has been done by IEP on selected vegetation and water at this application rate. The IEP data has not yet been analysed and published.

To supplement the IEP data, mountain mahogany, snowberry and white fir foliage samples were collected immediately after spraying and 1, 7, 14 and 28 days after spraying in 1 pound per acre treatment plots. (Photo 24). Also, water samples were collected from one 1-pound and two 3/4-pound treatment plots between immediately after and 98 to 338 hours after spraying. Residue analysis of the foliage and water samples were made in the IEP laboratories.

Tree samples consisted of a whole branch taken from the [illegible] tree. The [illegible] was quickly enclosed the branch in a [illegible] to capture all of the insects, spiders, [illegible] sealed the bag around the [illegible] base [illegible] [illegible] branch to the laboratory. (Photo 27). [illegible] cubic foot of material, collected by [illegible] bag. (Photo 27).

In the laboratory the specimens were separated [illegible] litter and stored in alcohol vials. (Photo 28) [illegible] samples were sorted by Order and Family [illegible] and then counted and identified the organisms by [illegible]

Residue Analysis - A great deal of data has been [illegible] forests on residues of [illegible] applied at the rate of [illegible] Some additional residue analysis has been done by [illegible] vegetation and water at this application rate. [illegible] analyzed and published.

[illegible] Lardeto, mountain mahogany, sticmer, [illegible] collected immediately after spraying and [illegible] spraying in 1 pound per acre treatment plots. (Photo 29). [illegible] col [illegible] from the 1-pound and [illegible] immediately after and 48 to 336 [illegible] after [illegible] of the foliage and water samples were made [illegible]

Photo 21. Forestry Aids Simonette and Pointer collect "lurch bag" sample.

Photo 22. UC technician Karen Zimmerer bagging litter sample.

Photo 23. UC Technician Connie Fisher separating organisms from "lurch bag" branches.

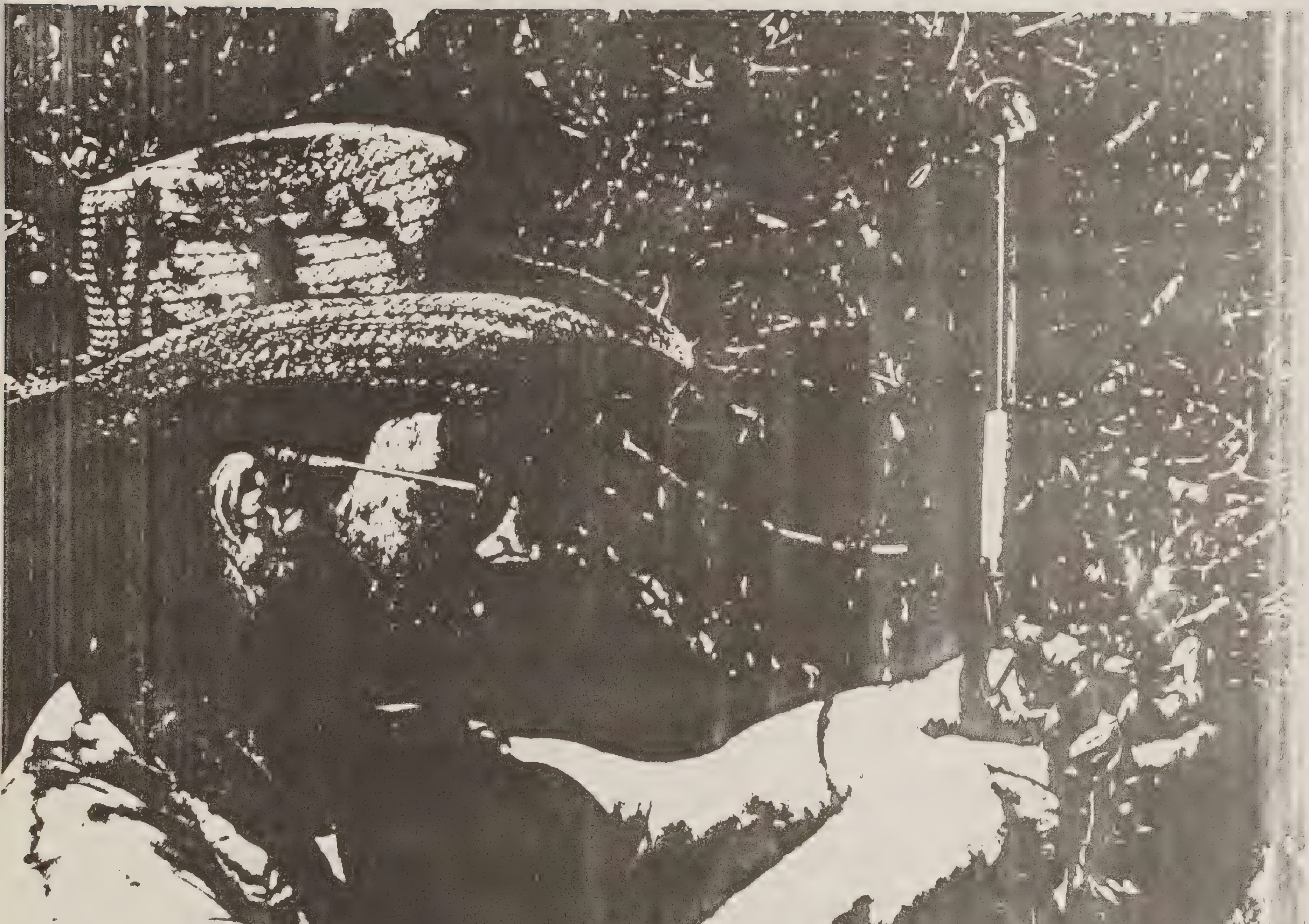


Photo 24. Forester Darwin Richards collecting mountain mahogany sample.

EFFICACY INVESTIGATIONS (RESULTS)

Test Design

Three replications of three treatments (including the non-spray treatment) was a simple and straight-forward test design most appropriate for use with the large plots employed for the spray test. One minor omission did arise under this test design which is noted and explained as follows.

The formulation of the Dylox sprays included a small quantity of Rhodamine B dye desolved in oleic acid added to facilitate spray monitoring activities. After the test was carried out, it came to our attention that oleic acid has been tested and found to have some insecticidal effects on the western spruce budworm, *Choristoneura occidentalis* Freeman (Andrews & Muskus - 1972). This suggests that the addition of a fourth treatment - the spray carrier formulation consisting of crop oil. Rhodamine B dye and oleic acid - could have appropriately been added to the spray test. Since this was not done, our efficacy data includes any mortality of Modoc budworm contributed by the carrier formulation.

TREATMENT PLOT SELECTION

Nine of the twelve originally established plots were used in the pilot control project (Figure 1). One deleted plot was not used because the owner of included private land objected to the test; and two other plots were judged unsuitable due to lower than average budworm populations. In addition, two of the utilized plots could serve only as check (unsprayed) plots because of their location on the border of the South Warner Wilderness.

[illegible] ... (continued)

[illegible]

[illegible] ... the [illegible] ... [illegible]

[illegible]

[illegible]

[illegible]

[illegible] Technique [illegible] ... [illegible]

monitoring activities. After [illegible] was com[illegible]

attention that plots [illegible] had been [illegible] found in

insecticidal effects on the western spruce budworm, [illegible]

occidentalis Freeman (Andrews & [illegible] - 1972). [illegible]

addition of [illegible] fourth treatment [illegible]

[illegible] Q. and [illegible] could have

been [illegible] in the [illegible]. Since [illegible]

data [illegible]

formulation.

[illegible]

[illegible] of the twelve originally established plots were used in the [illegible]

[illegible] project (Figure 1). The deleted plot [illegible]

[illegible]

[illegible]

[illegible]

DEVELOPMENT SAMPLING

Development and population assessment data accumulation began in mid-May 1974 from field samples collected from three trees per cluster, ten clusters per plot, from the twelve plots delineated for the field test. This information gathering effort merged and continued with the pre- and post-spray sampling program designed to show treatment efficacy when the spray applications were made.

Taxonomic studies made by Dr. J. Powell (Photo 25)--University of California taxonomist--show a total of twelve microlepidopters were involved in the Modoc infestation. The most common species existing on trees sampled for the pilot control project were the Modoc budworm *Choristoneura viridis* Freeman, and the spruce coneworm, *Dioryctria reniculella* (Grote). (Photo 26). Besides the two common species, Dr. Powell reports the following:

> "Enumeration of Lepidoptera Other Than Choristoneura and Dioryctria. The remainder of the caterpillar community consisted of the following ten species, and these comprised about 1.5% of the moths reared from prespray and postspray samples at Berkeley.
>
> Noctuidae - *Syngrapha celsa sierrae* Ottol.; Portricidae - *Epinotia meritana* Heinrich; *Epinotia hopkinsana* (Kearfott); *Acleris gloverana* (Walsingham); *Choristoneura lambertiana subretiniana* Obraztosov; *Parapandemis borealis* Freeman; *Argyrotaenia dorsalana* (Dyar); *Argyrotaenia provana* (Kearfott); Gelechiidae - *Chinodes* undescribed species near *tessa* Clarke; *Coleotechnites* species (differs from sp. near coniferella that was reared in the Warner Mountains in 1970 and mentioned in the proposal for the present project).

Photo 25. Dr. Jerry Powell studying specimens in the project laboratory.

Photo 26. Spruce coneworm (L) and Modoc budworm (R).

Laboratory workers were trained in identification of larvae by Dr. Thomas Eichlin, Systematic Entomologist, Division of Plant Industry, California Department of Food and Agriculture. They were also instructed in the recognition of larval growth stages (instars) for the target insect, the Modoc budworm, by Dr. Thomas Koerber, PSW; however, the recognition of instars was not imparted to them until specimens could be reared to the different stages in the laboratory. Early developmental stages were recorded by habitate; such as needle mining stage, attacking new buds stage. The ability to classify according to developmental stages was acquired during the third and fourth instars and the data is not reliable until the fifth instar since some of the third and fourth instar larvae were undoubtably recorded according to the improvised habitate system. For the purpose of the spray test, this laboratory work was fully adequate to guide spray application timing.

The project Pilot Test Plan (Swain, Pierce, Ollieu, 1974) recommended spray application before the pupal stage commenced and when the Modoc budworm larvae were 20 to 30 percent young larvae, 30 to 40 percent 5th instar and 20 to 30 percent 6th instar.

The theorized ideal mixture of developmental stages were difficult to pinpoint in the spray plots; but nevertheless the intent of the recommendation--to spray the most exposed larvae--was achieved. The actual timing of the spray application in relation to the developmental cycle of the Modoc budworm is shown in Figure 2.

[illegible]

in the periodicity [illegible]

insect, the [illegible] budworm, [illegible]

[illegible]

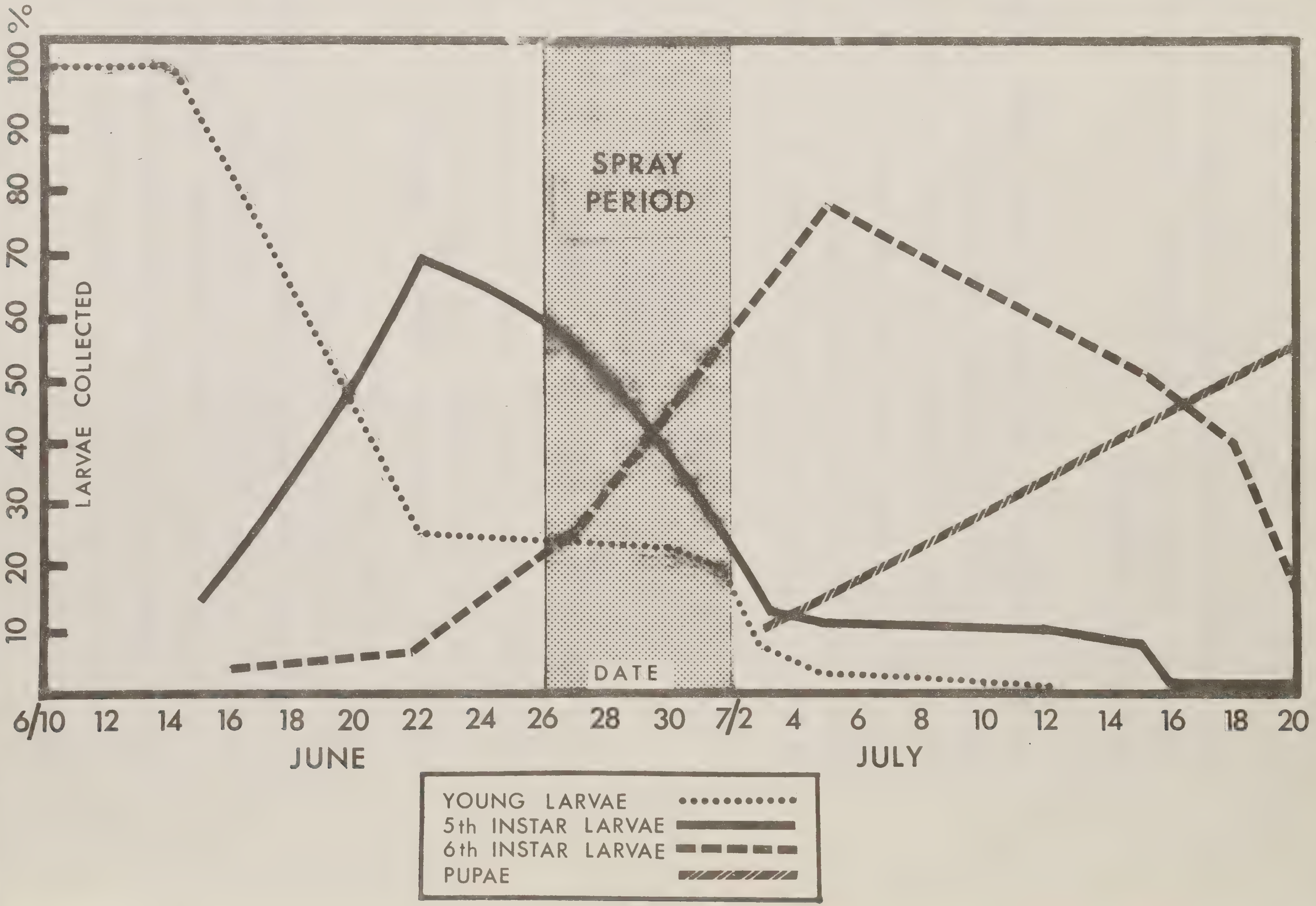
was fully [illegible] spray application timing

The project Pilot Test Plan (Swain, Pierce, Dilley, [illegible]) recommended spray application before the pupal stage [illegible] when the budworm larvae were [illegible] to 30 percent [illegible] percent [illegible] and [illegible] percent 5th instar.

The [illegible] ideal mixture of development stages [illegible] [illegible] in the spray plots, but [illegible] [illegible] of the recommended [illegible] spray, the most [illegible] [illegible] [illegible] timing of the spray application in relation to the developmental [illegible] of the [illegible] budworm is shown [illegible] 2

FIGURE 2

Spray Timing Relative to Budworm Development



SPRAY FORMULATION

The entire batch of spray needed for each formulation was mixed at one time and transported in turn to the spray plot helispots when needed. At each spray plot samples of the spray solution were taken when the helicopters were loaded and kept for later analysis of Dylox content by IEP laboratories. Sample analysis show that spray mixing and agitation were proper and effective as indicated below:

(1) 0.75 pound per gallon batch

Plot 1	Fandango Peak	average of 2 samples 0.73 lbs
Plot II	Benton Meadows	average of 2 samples 0.76 lbs
Plot III	Mill Creek	average of 2 samples 0.79 lbs

(2) 1.0 pound per gallon batch

Plot V	South Deep Creek	average of 2 samples 1.04 lbs
Plot IX	Long Valley	average of 2 samples 1.06 lbs
Plot XI	Manzanita	average of 2 samples 1.07 lbs

One possibly serious problem was encounter in regards to the Rhodamine dye solution. This solution is so concentrated that part of the dye settles out shortly after agitation stops. Consequently it is possible that the dye content of different loads of spray could vary from the intended 0.1% which in turn complicates spray deposit analysis by flourometric measurements. Also the dye formulation is highly disagreeable to work with.

SPRAY EQUIPMENT CALIBRATION

The equipment was calibrated to apply one gallon of spray solution per acre as discharged from the spray apparatus flying above the trees. The

spray deposites recovered at ground level averaged 0.93 gallons per acre according to the cards or 0.14 gallons per acre according to the aluminum plates.

Due to the physical properties of the spray the helicoper spray systems were unable to deliver a spray spectrum of small droplets. The spray apparatus performed well when 8002 size nozzles were used; but when the next smaller size nozzles-8015-were used the nozzles frequently plugged up. The project was carried out using the 8002 nozzles. The volume mean diameter (VMD) obtained averaged 308 with the 3/4 lb formulation and 344 with the 1 pound formulation, according to analysis of the spray cards.

SPRAY APPLICATION

The spray application contractor provided an efficient and professional quality service in transporting and applying the spray solution. We are reasonably sure that the correct volume of solution was sprayed over the intended area of ground as evenly dispursed as could be expected. Flying errors causing violations of stream buffer zones resulted primarily from communication breakdowns rather than flying skill deficiencies.

In a similar vein, the inability to dispense the spray solution in a spectrum of small droplets is directly related to the physical properties of Dylox and was a shortcoming that could not be corrected in conventional spray equipment.

PRE-AND POST-SPRAY SAMPLING

The insect populations were sampled 24 hours prior, and 6 and 16 days after spray application. In addition adult moth's were trapped, then following the moth flight period, Modoc budworm egg populations were

ous. (c): measured at ground level averaged 0.03 gallons per

ording to the reports or 0.14 gallons per acre according to the

aluminum plates.

Due to the physical properties of the spray the helicopter spray systems were unable to deliver a spray spectrum of small droplets. The spray apparatus performed well when 2002 size nozzles were used; but when the smaller size nozzles were used the nozzles frequently plugged up. The project was carried out using the 2002 nozzles. The volume mean diameter (VMD) obtained averaged 308 with the 3/4 lb formulation and 344 with the 1 pound formulation, according to analysis of the spray cards.

SPRAY APPLICATION

The spray application contractor provided an efficient and professional quality service in transporting and applying the spray solution. We are reasonably sure that the correct volume of solution was sprayed over the intended area of ground as evenly dispersed as could be expected. The errors causing violations of stream buffer zones were, for the most part, primarily from communication breakdowns rather than flying skill deficiencies.

As stated, the inability to disperse the spray solution in a spectrum of small droplets is directly related to the physical properties of Sylvi and was a shortcoming that could not be corrected in conventional

74 hours or less, and 6 and 15 days

for adult moths, ... eggs ... were

sampled in sprayed and unsprayed areas about two months after the spray was applied. A reduced sampling program was also carried out the following year (1975) to check on the longer term effects of treatment on the budworm and associated microlepidoptera.

The population sampling data which best indicates the efficacy of the Dylox treatment for Modoc budworm suppression is a comparison of the 6-day post spray sample and the pre-spray sample. An analysis of this data is as follows:

TABLE 1: EFFECT OF DYLOX TREATMENTS ON THE MODOC BUDWORM

Treatment 2/		POPULATIONS 1/		
	Pre-Spray	6-Day Post Spray	Percent Reduction	Percent Control 3/
1 pound	76.85	2.17	97.18	88.62 ± 8.08 4/
3/4 pound	92.55	9.76	89.45	68.36 ± 12.33 4/
Zero	86.57	32.99	61.89	0.00

1/ Budworms per 1,000 square inches of foliage.

2/ Weight (AI) of Dylox applied per acre.

3/ Percent control due to Dylox calculated by Abbotts Formulae which compares sprayed and unsprayed populations before and after treatment to determine the portion of the population decline attributable to the spray treatment.

4/ Value based on 30 observations, ie, ten tree clusters times three plots for each spray treatment.

The above results are probably a conservative estimate of Dylox effectiveness against the Modoc budworm. Because of the large decline in budworm populations in unsprayed check plots used for comparison, mortality caused by the Dylox treatments could be partly obscured in the data by naturally caused mortality. Moreoever the statistics do show a significant difference between sprayed and unsprayed populations:

TABLE II: MULTIPLE RANGE TEST AND F RATIO

Treatment	UPPER & LOW LIMITS OF POPULATION REDUCTION		
	UPPER	LOWER	MEAN
1 pound	100.00%	89.43%	97.18
3/4 pound	95.77	81.47	89.45
Zero pound	70.66	56.36	61.89
F Ratio	Treatment = 57.71** Table (.01 level) = 4.89		

** Differences between treatments are highly significant.

Sticky traps were deployed widely in the infested area during late July to mid-August 1974. These traps were baited with pheromone preparations supplied by Dr. Gary Daterman of the Pacific Northwest Forest and Range Experiment Station. The results of this survey are summarized in Table III. This moth-trapping survey provided a signal for initiating the egg-sampling survey by indicating the end of the moth flight period.

As can be seen by the figure in Table III, there is not an apparent correlation between the numbers of moths caught in traps and the subsequent egg populations estimated by sampling in the same areas. Since one expects a strong relationship between two adjacent stages of a life cycle to exist, the dissimilarities shown in Table III, probably are due to inadequate sampling or faulty technique or timing; this being the first extensive attempt to trap Modoc budworm moths.

Several other moths also were trapped in large numbers, actually exceeding the number of budworm moths trapped in some cases. The four most common ones were identified by Dr. Thomas D. Eichlin, Systematic Entomologist for the California Department of Food and Agriculture, as follows:

Petri dish B_1 = species of Pterophoridae
Oidaematophorus mathewianus Zell. and/or
O. cretidactylus Fitch
Oidaematophorus rileyi Fern

Petri dish P_1 = Tortricidae
Sparganothis sp. prob. *californiana* Wlshm.

Petri dish R_1 = Ethmiidae
Ethmia monticola (Wlshm.)

... deployed widely in the infested area during 1974

mid-Aug. 1974. These traps were baited with pheromone

preparation supplied by Dr. Daterman of the Pacific Northwest

Forest and Range Experiment Station. The results of this survey are

summarized in Table III. This method of survey provided

for initiating the eradication survey by [illegible]

period.

As can be seen by the figures in this table, [illegible]

correlation between the number of moths [illegible] traps

subsequent egg population es[illegible] the [illegible]

Since one expects [illegible] strong [illegible] between [illegible]

life cycle [illegible], the [illegible] relationship found in Table III, [illegible]

are due to inadequate sampling [illegible] technique of [illegible]

the first extensive attempt [illegible] Modoc County [illegible]

Several other moths also were trapped in large numbers. [illegible] expansion

the number of Douglas-fir tussock moths trapped in some [illegible] four most

ones were identified by Dr. Thomas D. Eichlin, Systematic Entomologist

for the California Department of Food and Agriculture, as follows:

1. [illegible] = [illegible]

Orgyia pseudotsugata, 2911.

Table III. Number of Moths Trapped Compared to Egg Mass Populations:

Plot	Treatment	Moths (1)	Eggs (2)
VI	zero	1.26	5.81
VII	"	0.45	7.72
XII	"	1.28	8.07
I	3/4 lbs.	0.71	6.93
II	"	0.81	3.16
III	"	0.65	7.25
V	1 pound	0.57	1.04
IX	"	0.55	3.56
XI	"	2.12	1.41

(1) Moths per trap day (Mean)

(2) Egg masses per 1000 sq. in. of foliage (Mean)

The results of the egg population survey show that the Dylox treatment also reduced the initial stage of the next generation of budworm in treated areas:

TABLE IV: EFFECT OF DYLOX TREATMENTS ON THE SUCCEEDING BUDWORM EGG POPULATION

Treatment 2/	Egg Populations 1/	Number of Trees Sampled
1 pound	1.8 ± 0.7	45
3/4 pound	5.7 ± 1.8	46
Zero pound	9.8 ± 1.7	139

1/ Modoc budworm egg masses per 1,000 square inches of foliage

2/ Weight (AI) of Dylox applied per acre

Analysis of the data regarding the results of Dylox treatment on the spruce coneworm are as follows:

TABLE V: EFFECTS OF DYLOX TREATMENT ON THE SPRUCE CONEWORM

Treatment 2/	POPULATIONS 1/				
	Pre-Spray	6-Day Post-Spray	Multiple Range Test		
			Upper	Lower	Mean 3/
1 pound	78.62	0.96	100.00	90.66	98.41
3/4 pound	126.59	7.75	100.00	86.83	94.58
Zero pound	61.37	5.36	97.42	81.92	89.67
F Ratio	Treatment = 3.04* Table = 4.89				

* Differences between treatments are not significant.

1/ Coneworms per 1,000 square inches of foliage.

2/ Weight (AI) of Dylox applied per acre.

3/ Percent reduction of coneworm numbers.

Even though the one pound treatment shows a 98 percent reduction in spruce coneworm numbers following treatment, statistical analysis cannot show a significant difference between treatments. This is because the precipitous decline in coneworm populations in unsprayed check plots masks the mortality probably caused by Dylox. No attempt is made to calculate percent control by Abbott's Formulae.

In 1975 larval sampling was carried out between early June and the end of July. The objective of this 1975 sampling was to compare population densities of the various microlepidoptera in 1975 with the populations measured one year earlier, prior to spray applications, in 1974. Considering the different distributions and the different rates of development of all the insects of interest, this objective could entail sampling schemes too complex and detailed for accomplishment with the available resources. What was done was arbitrarily two thirds of the plots and one half of the clusters and one third of the trees in those clusters were sampled on a regular schedule.

As the sampling began it was found that the most significant change in densities had occurred to white fir needle miner populations in a portion of the budworm epidemic area. A special collection was made in a previously unsampled area--Cottonwood Creek--to further investigate this increase. For the other microlepidoptera the most revealing comparison was found between collections made from the same trees in the 1974 pre-spray sample and the 1975 sample collected nearest to the same time of year. The grouping used for this comparison were (1) modoc budworm; (2) spruce coneworm; (3) white fir needle miner and (4) associated microlepidoptera. The results of this work are reported in Figures 3

such a significant difference between Sample [illegible] This is [illegible] precipitous decline in common [illegible] masks the mortality probably [illegible] by [illegible] calculate percent control by Abbott [illegible]

In 1975 larval sampling was carried out between [illegible] of July. The objective of this 1975 [illegible] densities of the various microlepidoptera [illegible] measured one year earlier, prior to spray applications, in 19[illegible] Considering the different distribution [illegible] development of all the insects [illegible] sampling schemes too complex and data [illegible] available resources. What was done was [illegible] plots and one half of the clusters and [illegible] clusters were sampled on a regular schedule.

As the sampling began it was found that the most significant change in densities had occurred to white fir needle miner populations in a portion of the budworm epidemic area. A special collection was made in a previously unsampled area--Cottonwood Creek--to further investigate this increase. For the other microlepidoptera the [illegible] sampling comparison [illegible] found between collections made from the same trees in the 1974 [illegible] sample and the 1975 sample collected nearest to the same time of [illegible] used for this comparison were (1) [illegible] budworm; [illegible] white fir needle miner [illegible] (4) [illegible] [illegible] in Figures 3

through 6, which show population levels found in the three sampling periods in treatment plots receiving zero, three quarters and one pound of Dylox per acre. Plot XIII is the added plot, in 1975, sampled to evaluate the white fir needle miner outbreak.

(1) Modoc budworm (Choristoneura viridis Freeman) - Figure 3
In unsprayed areas the population densities were in one case greater and in one case lesser than those found in 1974. The 1975 populations were about 40 to 50 budworms per 1000 square inches of foliage in unsprayed areas. In all sprayed areas the population densities were reduced from the levels found in 1974 and, in all cases, except one, were considerably less than the 40 to 50 budworms per 1000 square inches found in unsprayed areas. The exceptional area was Benton Meadows. Benton Meadows had a 1975 population density of 53.5 budworms per 1000 square inches of foliage. It had been treated with 3/4 pounds of Dylox per acre and the spray deposits monitored with spot cards were the lightest deposites recovered in the spray test.

The highest populations levels found in 1975 in the 1 pound treatment areas were from South Deep Creek where a rain storm occurred on the plot a few hours after spray application in 1974. This rain, we believe, washed significant amounts of the Dylox spray from the trees.

(2) Spruce coneworm (Diorcyctria reniculella (Grote))- Figure 4.
In all plots, except one, the spruce coneworm populations were found to be higher in 1975 than in the same period in 1974 despite the large population reduction following spraying. The population levels were generally higher in sprayed areas than in unsprayed areas also in 1975; but considering the fact that the coneworm was originally more abundant

through 6, which show population levels found in the three sampling period[illegible] in treatment plots receiving zero, three quarters and one pound of Dylox per acre. Plot 4-11 is the added plot, in 1975, sampled to evaluate the white fir needle miner outbreak.

(1) Maine budworm (*Choristoneura viridis* Freeman) - Figure 3

In unsprayed areas the population densities were in one case greater and [illegible] one case lesser than those [illegible] in 197[illegible]. The 1975 populations were about [illegible] to [illegible] budworms per 1000 square inches of foliage in unsprayed areas. In all sprayed areas the population densities were reduced from the levels found in 1974 and in all cases, except one, were considerably [illegible] than [illegible] to [illegible] budworms per 1000 square inches found in unsprayed areas. The exceptional area was Benton Meadows. Benton Meadows had a 1975 [illegible] lation density of 53.5 budworms per 1000 square inches of foliage. It had been treated with [illegible] pounds of Dylox per acre and the spray deposits monitored with spot cards were the lightest deposites recovered in the spray test

The highest populations levels found in 1975 in the [illegible] pound [illegible] area, were from South Fork Creek where a rain storm occurred on the plot a few hours after spray application in 1974. This rain [illegible] of the Dylox spray from the trees.

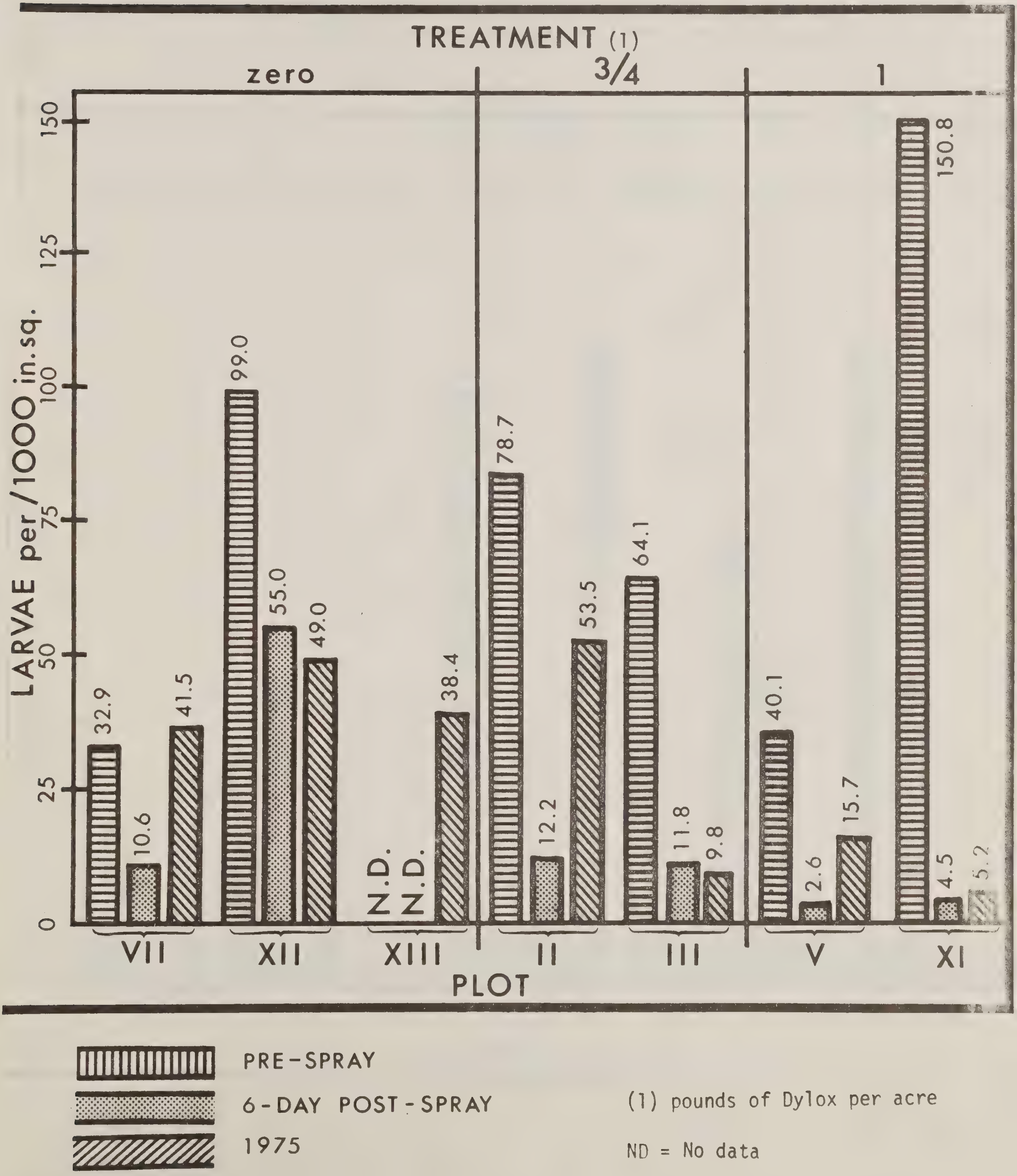
[illegible] cone worm (*Dioryctria [illegible]*) - Figure 4

[illegible] the spruce cone worm populations were found [illegible] the same period in 1974 despite the [illegible]

[illegible]. The [illegible] levels were [illegible] sprayed areas [illegible] 1975.

[illegible] significantly not [illegible]

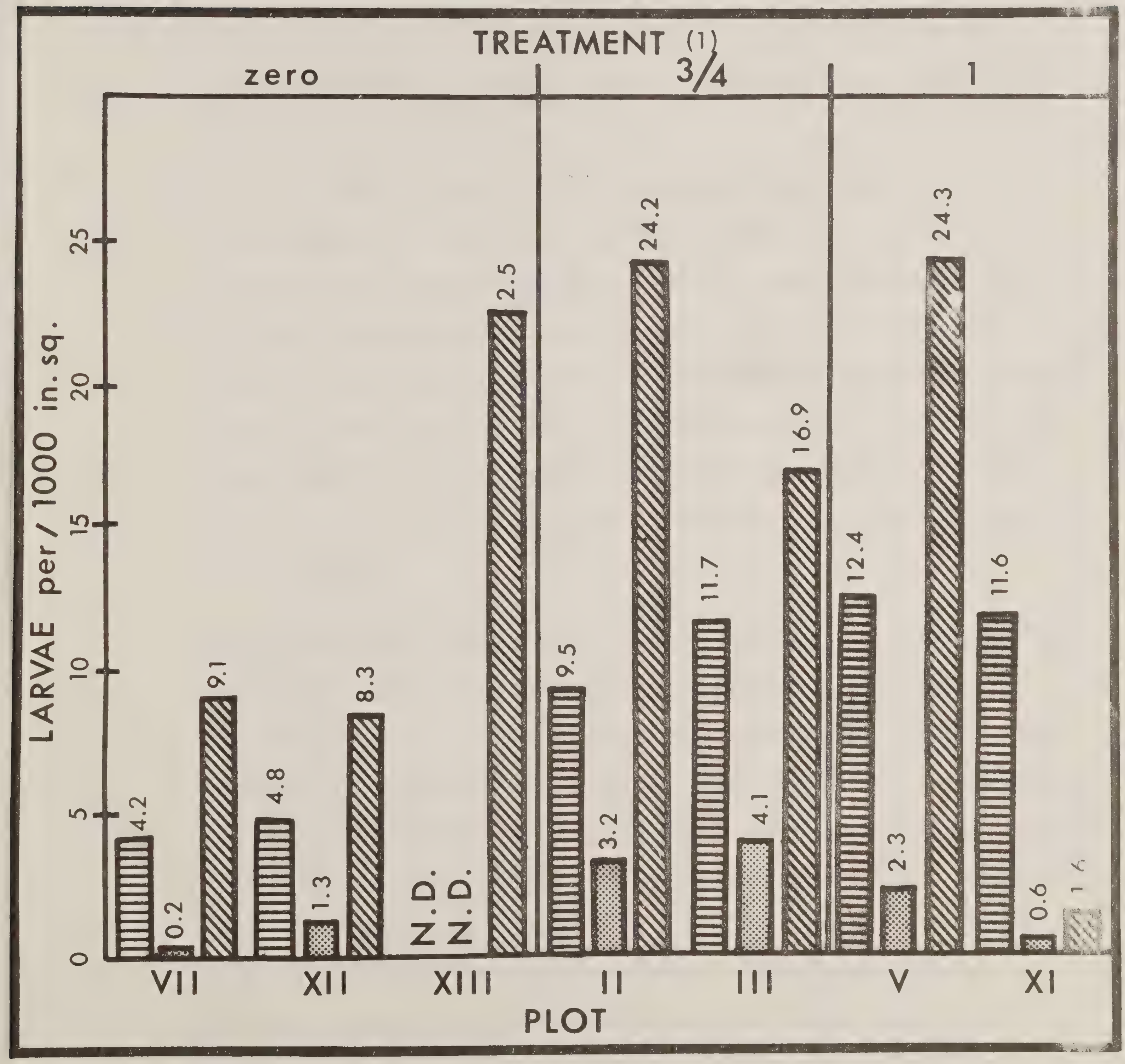
Figure 3. Variations in Modoc budworm larval populations according to treatments, as determined by three sampling periods.



(1) pounds of Dylox per acre

ND = No data

Figure 4. Variations in spruce coneworm larval populations, according to treatments, as determined by three sampling periods.



PRE-SPRAY

6-DAY POST-SPRAY

1975

(1) pounds of Dylox per acre

ND = No data

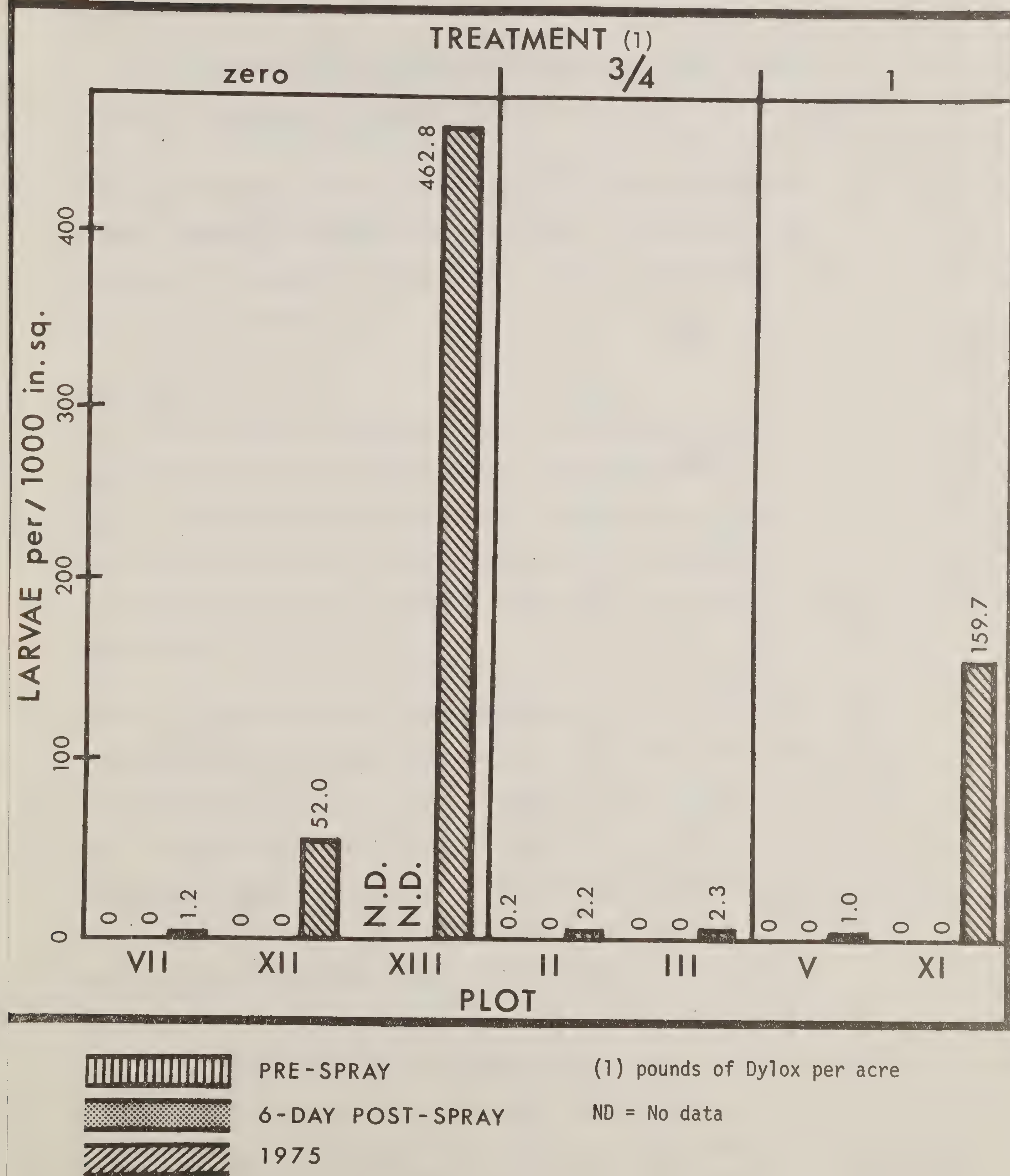
in sprayed areas, the percent increases was less in sprayed areas than in unsprayed areas.

The exceptional plot was Manzanita Mountains where the condworm was found at its lowest level in 1975, possibly due to the spraying. The timing of the spray may be important in accounting for this effect because the Manzanita Mountain plot was the earliest spray application made.

(3) White fir needle miner (Epinotia meritana Henrick). Figure 5. The development of the white fir needle miner in the spring is decidedly more advanced than that of the other microlepidoptera. When pre-spray samples were collected in 1974, nearly all of the needle miners had completed development and emerged and the pre-and post-spray counts for this moth were zero in all plots except one. The 1975 values reported are the highest, and usually the earliest collections made; so in this case a direct comparison between 1974 and 1975 data is not intended.

Upon visiting the field in 1975, it was almost immediately apparent that a white fir needle miner epidemic existed over about 8000 acres. Manzanita Mountain (1 pound Dylox per acre treatment) lay in the northern part of this outbreak and Snell Springs (0 pound Dylox per acre treatment) was in the southern portion. An additional collection was made, consisting of 4 twigs from each of three trees at eight locations (total 24 trees), from the middle of the outbreak. This area, Cottonwood Creek, had not been sprayed in the pilot control project. Needle miner populations were high at Snell Springs (52 per 1000 sq.in.), still higher at Manzanita Mountain (197 per 1000 sq.in.) and startlingly high

Figure 5. Variations in white fir needle miner larval populations, according to treatments, principally for 1975.



(1) pounds of Dylox per acre

ND = No data

(463 per 1000 in.sq.) at Cottonwood Creek, the centrally located sampling unit.

(4) Associated microlepidoptera (chiefly Parapondemis borealis Freeman and Argyrotoenia dorsalana (Dylar)) - Figure 6.

Population densities of other associated moths of the Modoc budworm epidemic apparently fluxuated both up and down in non-treated areas but generally increased in sprayed areas. However, these changes were not in any case large.

DROP CLOTHS*

Drop cloths erected to sample the insects falling from the trees after application provided immediate evidence of the effectiveness of the spray. On the spray plots large numbers of insects accumulated in the drop cloths within hours after spraying while on the unsprayed plots very few insects appeared in the drop cloths but large amounts of frass accumulated.

The data on frass drop show a sharp reduction in the rate of accumulation on sprayed plots in the days following spray application (see Table VII). The reduction in the rate of frass accumulation occurred sooner in the plots receiving one pound per acre of Dylox than in the plots receiving three-fourths pound per acre, ie, during the second sampling period the rate of frass fall was significantly higher on the three-fourths pound plots than on the one pound plots. Differences were smaller and not significantly different in the third sampling period. The rate of frass accumulation on the plots receiving one pound per acre of Dylox was reduced 93.2 percent in comparison with the unsprayed plots during the third sampling period. On the three-fourths pound blocks the reduction during

*Information provided by Dr. Thomas Koerber, PSW, who directed the investigation.

1000 ft.sq.) at Coal Creek, the centrally located ...ling unit.

(4) Associated microlepidoptera (chiefly *Zeiraphera* ... Freeman and *Argyrotaenia dorsalana* (Dyar)) - Figure 6.

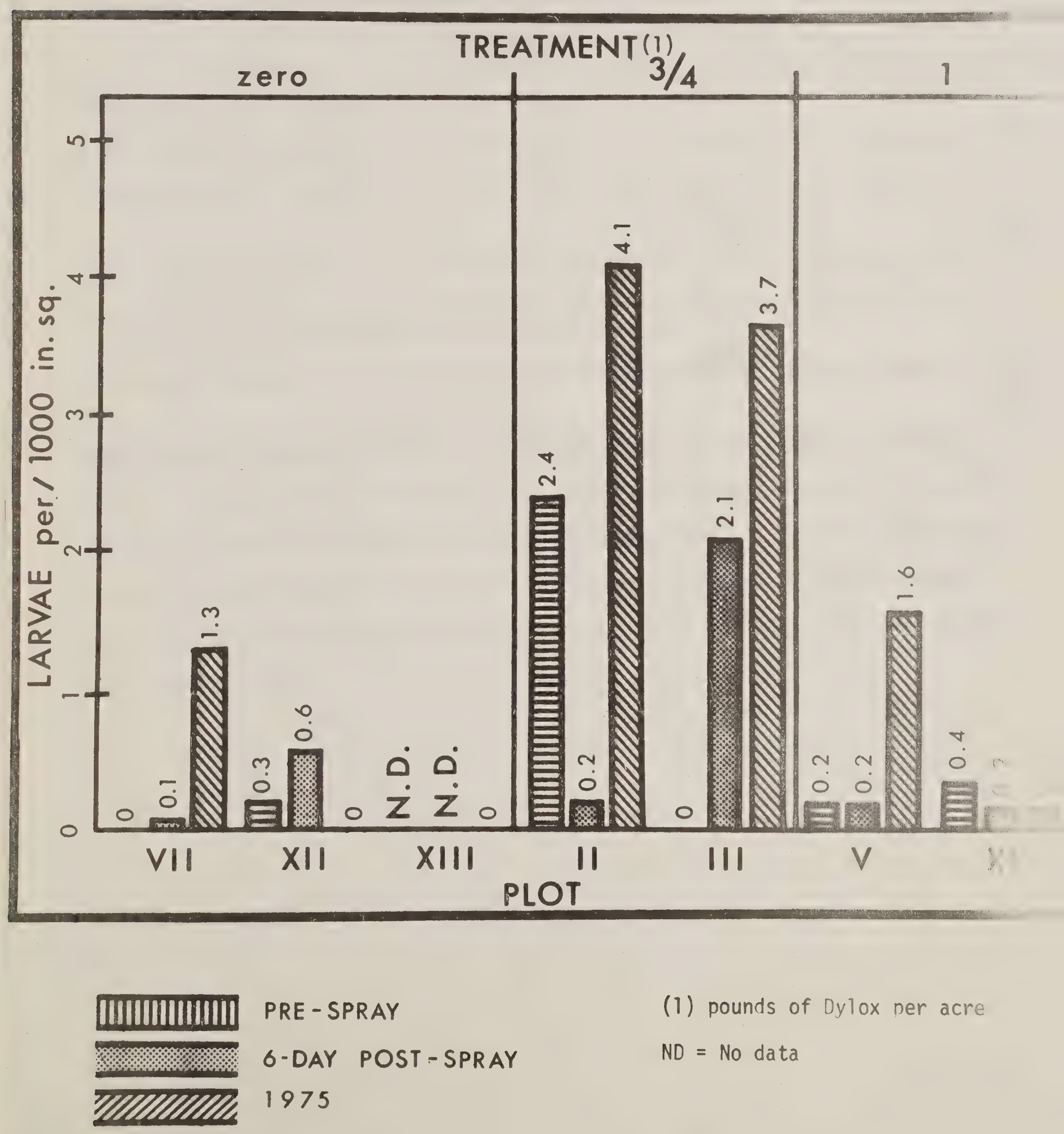
Population densities of other associated moths of the Nokt... epidemic apparently fluctuated both up and down in non-treated areas but generally increased in sprayed areas. However, these changes ... not in any case large.

DROP CLOTHS

Drop cloths erected to sample the insects falling from the trees after application provided immediate evidence of the effectiveness of the spray. On the spray plots large numbers of insects accumulated in the drop cloths within hours after spraying while on the unsprayed plots very few insects appeared in the drop cloths but large amounts of ... accumulated.

The data on frass drop show a sharp reduction in the rate of accum... on sprayed plots in the days following spray application (see Table ...). ...duction in the rate of fras... ...lation occurred sooner ... than in the plots ... during the second sampling period ... ...ficantly higher on the three-... ...plots. Differences were smaller and ... the third sampling period. The rate ... one pound per acre of ... plots during the third ... reduction

Figure 6. Variations in larval populations for other associated microlepidoptera, according to treatments, as determined by three sampling periods.



(1) pounds of Dylox per acre

ND = No data

TABLE VI--THE RATE OF FRASS ACCUMULATION PER DROP CLOTH DURING 3 TWO-DAY PERIODS AFTER SPRAY APPLICATION (MEAN VALUES)

Treatment	GRAMS OF FRASS PER COLLECTION (1)			
	First Period	Second Period	Third Period	Total
Dylox 1 lb.	1.57 (a)	0.23 (a)	0.24 (a)	2.03 (a)
Dylox 3/4 lb.	2.30 (a)	0.74 (b)	0.32 (a)	3.29 (a)
Untreated (2)	3.55 (a)	3.55 (c)	3.55 (b)	10.66 (b)

(1) Figures adjacent to the same letter (a) in each sampling period are not significantly different at the 95 percent level.

(2) Composit sample for entire six days prorated evenly among the periods.

Modoc budworm larvae were by far the most abundant insects caught in the drop cloths. Most of these were caught during the first two-day period after spraying, indicating immediate action of the spray on these insects. However, considerable numbers of larvae appeared in the drop cloths during the third period suggesting that the insecticide was still killing larvae four to six days after application (see Table VII).

TABLE VII. EFFECTIVE TIME STUDY

The number of Modoc Budworm larvae caught per drop cloth during 3 two-day periods after spray application. (Mean Values)

Treatment	First Period	Second Period	Third Period	Total
Dylox 1 lb./A	121.5	21.2	12.2	154.9
Dylox 3/4 lb./A	113.4	29.6	5.8	148.8
Untreated (1)	5.9	5.9	5.9	17.7

(1) Composit sample for entire 6 days prorated evenly among the periods.

The pattern of the data on numbers of spruce coneworm larvae caught is similar to that of the Modoc budworm. The drop cloths on the one pound per acre plots caught an average of 1.2 larvae during the third sample period. This is four times the rate on the unsprayed plots, suggesting continued insecticidal activity.

TABLE VIII. EFFECTIVE TIME STUDY

The number of spruce coneworm larvae caught in drop cloths during 3 two-day periods after spray application. (Mean Values)

Treatment	First Period	Second Period	Third Period	Total
Dylox 1 lb./A	15.6	1.4	1.2	18.1
Dylox 3/4 lb./A	26.4	3.6	0.6	30.6
Untreated (1)	0.3	0.3	0.3	0.9

(1) Composit sample for entire 6 days prorated evenly among the periods.

Adult scarab beetles, elaterid beetles and flies were considered to represent groups of insects which were in the pupal stage in the soil where they would not be contacted by the spray, but would be emerging as adults more or less continuously into the above ground environment to come in contact with the spray deposit. Hopefully, over a short period, the supply of insects in these groups would not be depleted like a species where all the individuals were exposed at the time of spraying.

The number of scarab beetles caught in the sprayed plots decreased to a fraction of what was caught in the unsprayed plots, probably indicating that emergence was not continuing and the supply of beetles was depleted (see Table IX).

The number of elaterid beetles caught in the sprayed plots declined to numbers only slightly higher than those obtained on the unsprayed plots probably indicating only slight mortality from the spray after four days (see Table IX).

The number of flies caught on the sprayed plots remained much higher on the sprayed plots than on the unsprayed plots through all the sample periods. The minimum spray plots catch, 3.6 flies per drop cloth, was in the 3/4 lb. per acre Dylox treatment. This was 18 times the catch on the unsprayed plots (see Table IX). The minimum catch of flies on any spray plot during the last sample period was five times the number from the unsprayed plots. Clearly the insecticide deposit was still killing flies during the period four to six days after spray application.

[illegible] beetle, elaterid beetles and flies were considered to represent groups of insects which were in the pupal stage at the [illegible] they would not be contacted by the spray, but would be emerging as adults more or less continuous [illegible] into the above ground environment to come in contact with the spray deposit. Hopefully, over a short period, the supply of insects in these groups would not be depleted like [illegible] where all the individuals were exposed [illegible] the time of spraying.

The number of scarab beetles caught in the sprayed [illegible] fraction of what was caught in the unsprayed plot. Probably that emergence was not continuing and the supply [illegible] (see Table IX).

The number of elaterid beetles caught in the sprayed plots [illegible] numbers only slightly higher than those obtained on the unsprayed plots probably indicating only slight mortality from the spray after [illegible] days (see Table IX)

The number of flies caught on the sprayed plots remained much higher on the sprayed plots than on the unsprayed plots through all the sample periods. The minimum spray plots catch, 3.6 flies per drop cloth, was in the 3/4 [illegible], per acre Dylox treatment. This was [illegible] times the catch [illegible] unsprayed plots (see Table IX). The minimum catch of flies on [illegible] the last sample period was five times the number [illegible] plots. Clearly the insecticide deposit was still [illegible] four to six days [illegible] spray application.

Counts of ants caught in the drop cloths were included because of the observation that ants may be important predators of the Modoc budworm. The number of ants caught in the sprayed plots was not much higher than in the unsprayed plots (see Table IX). It was further observed that many ants climbed into the drop cloths from the ground and were trapped rather than falling from the trees. Therefore, the number of ants in the samples may be an indication of the effectiveness of the drop cloths as ant traps as well as the effect of the insecticide on ants.

ts caught in the drop [illegible] were found [illegible]

observation that ants may be [illegible] predators of the Mohor

The number of ants caught in the sprayed plots was not much hi

in the u prayed plots (see Table IX). It was further observe

many ants climbed into the drop cloths from the ground [illegible]

rather than falling from the trees. Therefore the numb

the [illegible] may be an indication of the effectiveness [illegible]

of ant traps as well as the effect of the insecticide on

TABLE IX. EFFECTIVE TIME STUDY

Other Selected Insects Caught per Drop Cloth during 3-two day Periods after Spray Application

Type of Insect	Collection Period	Treatment		
		1 lb.	3/4 lb.	Untreated (1)
Scarabs	1st	11.0	15.0	3.8
	2nd	3.3	6.0	3.8
	3rd	0.6	1.3	3.8
	Total	14.9	22.3	11.4
Elaterids	1st	8.7	9.7	2.3
	2nd	3.3	4.0	2.3
	3rd	3.0	2.7	2.3
	Total	15.0	16.4	6.9
Flies	1st	10.2	13.0	0.2
	2nd	5.0	4.4	0.2
	3rd	3.8	3.6	0.2
	Total	19.0	21.0	0.6
Ants	1st	8.1	14.6	4.1
	2nd	3.0	4.8	4.1
	3rd	3.6	5.2	4.1
	Total	14.7	24.6	12.3

(1) Composit sample for entire 6 days prorated evenly among the periods.

SPRAY CARDS AND PLATES

Deploying, retrieving, processing and analyzing spray cards and plates, proved to be the second most laborious and expensive activity of the pilot control project; second only to insect population assessment activities.

·Prompt deployment and retrieval of spray cards and plates required a work force of about 16 workers and 8 vehicles during spray application periods.

·Processing and reporting results from the aluminum plates was reasonably prompt. However, the processing of the spray cards was not satisfactory. Apparently the Modoc budworm project was the first, or an early attempt, to computer process these cards at the U.C. Davis facility. Incorrect readings were first reported and a reasonable spray deposit report was not received until almost 18 months after field work was completed.

·Analysis of information obtained from the two spray monitoring methods - aluminum plates and paper cards - was useful in determining relative dosages.

Table X summarizes the average gallons per acre reported by each method for the six spray plots. Obviously there is a calibration problem since the cards report about six times as much spray as the plates; but also the ratio between the cards and plates is not consistent either although the cards and plates for each tree were positioned within inches of each other. For individual trees the spray deposit rates between cards and plates varied from 2 to 1 to 50 to 1.

A few of the spray cards positioned in non-sprayed check areas were reported to show spray deposits. For one card a deposit of 0.81 gallons per acre was reported; however visual inspection of this card showed no dye spots and comparison of this card with another showing 0.8 gallons per acre clearly indicates this computer reading was incorrect. Other cards from check areas were reported to have 1 to 3 spots but these could not be found when the cards were inspected under 6 power magnifications. However, most of the cards from check areas were reported to show zero deposits.

Inspection of the spray card and plate data clearly shows two additional important facts:

·Nearly every tree monitored for spray deposits in the sprayed plots did receive some spray.

·Spray deposits reported from Plot II (Benton Meadows) were obviously less than the average applied to the other plots.

Table X

AVERAGE SPRAY DEPOSITS

	PLOT	SPRAY CARDS (1)	ALUMINUM PLATES (1)	RATIO CARDS TO PLATES
I	Fandango Peak	0.8124	0.1076	7.55 to 1
II	Benton Meadows	0.3389	0.0524	6.46 to 1
III	Mill Creek	1.0684	0.2128	5.02 to 1
V	South	1.1312	0.1365	8.29 to 1
IX	Long Valley	1.4866	0.1076	8.77 to 1
XI	Manzanita Mountain	0.7502	0.2139	3.51 to 1

(1) gallons per acre

ESTIMATES OF FOLIAGE CONSERVATION

Ocular estimates of foliage lost, on a damage scale of 0 to 3, is presented in Table IX. Both old and new foliage were considered by the estimators when the data was recorded in the field. Damage ratings were recorded in the field only as whole numbers (0 to 3) but averaging converts these ratings into decimals reported here.

This work documents that both new and old foliage were lost. While the numbers suggest that feeding on new needles is most extensive, it must be kept in mind that new foliage represents one year's growth but old foliage represents several years' growth; so feeding on new and old needles must be more nearly equal than expected.

Beneficial effects of saving foliage by spraying is not clearly shown by these data. In one case a decrease in feeding on old needles between pre-spray and post-spray estimates is shown and more severe defoliation in sprayed areas than in unsprayed areas is indicated in some instances. Apparently these estimates reflect defoliation conditions which are pretty much the same in sprayed and unsprayed plots.

ESTIMATES OF FOLIAGE CONSUMPTION

Ocular estimates of foliage lost, on a damage scale of 0 to 3, is presented in Table IX. Both old and new foliage were considered by the estimators when the data was recorded in the field. Damage ratings were recorded in the field only as whole numbers (0 to 3) but averaging converts these ratings into decimals reported here.

This work documents that both new and old foliage were lost. While the numbers suggest that feeding on new needles is more extensive, it must be kept in mind that new foliage represents one year's growth but old foliage represents several years' growth; so feeding on new and old needles must be more nearly equal than expected.

Beneficial effects of saving foliage by spraying is not clearly shown by these data. In one case a decrease in feeding on old needles between pre-spray and post-spray estimates is shown and more severe defoliation in sprayed areas than in unsprayed areas is indicated in some instances. Apparent [illegible] estimates reflect defoliation conditions which are pretty much the same in sprayed and unsprayed plots.

Table XI

Defoliation Estimates
Mean of the Scores Recorded by Estimators (1)

Treatment	Pre-Spray		6-day post-spray		16-day post-spray	
	New Needles	Old Needles	New Needles	Old Needles	New Needles	Old Needles
1 lb.	2.09	0.89	2.46	1.06	2.55	1.72
3/4 lbs.	2.49	1.08	2.69	1.13	2.94	1.38
Zero lbs.	2.42	1.23	2.71	1.06	2.90	1.45

(1) Midcrown

Laboratory recorded damage ratings, based on shots damaged on a scale of 0 to 3, is shown in Table XII. This data also reflects a damage conditions which did not change greatly between samples taken in sprayed and unsprayed areas or before and after spraying. For example a reduction in damage between the 6-day and 16-day post-spray samples is shown. However there was no evidence of the trees refoliating, so this improvement is mearly an artifact resulting from normal variations caused by different people recording damage estimates.

Table XII Defoliated Shoots Recorded from Branch Samples (1)

	Pre-Spray	6-Day Post-Spray	16-Day Post-Spray
1 lbs.	2.72	2.86	2.76
3/4 lbs.	2.84	2.88	2.84
Zero lbs.	2.79	2.95	2.93

(1) $\frac{\text{defoliated shoots}}{\text{Total shoots}} \times 3$

GROWTH-LOSS INVESTIGATIONS*

Initial comparisons of annual growth patterns of host and non-host trees -- sampled in old infestations with the intent to compare defoliated and undefoliated trees -- indicate that white fir suffered growth losses due to defoliation. In years when defoliation was reported most severe, the height increment loss (20-50%) generally exceeded the radial increment loss (10-40%).

Cumulative volume losses over the past 25 years, the period covered by pest records, averaged roughly 7 percent. This amounted to 0.4 meters (3%) of total tree height and 3.0 millimeters (3%) of tree radius.

Growth lags in fir ostensibly from defoliation, appear associated with one or more years of subnormal precipitation.

Results obtained so far are tentative and incomplete and are based on sample trees chosen without knowledge -- on the individual tree level -- of the actual amount of defoliation sustained by the trees. Additional sampling in the future can increase the sample size and take advantage of defoliation records for individual trees obtained in 1975.

WEATHER FORECASTING AND MONITORING

Significant weather events encountered during the application phase of the project were as follows:

1. The first day's spraying had to be cancelled because of excessive winds at the heliport. The heliport was located on an exposed ridge about a 1/2-mile off the treatment plot.
2. Excessive air turbulence at one treatment block was detected

*Information provided by Dr. George Ferrell, PSW, who is conducting the investigation.

in time to prevent dispatching crews and equipment.

3. An afternoon application was tentatively scheduled on the basis of a forecast. However, excessive temperatures were measured on the plot in time to halt the initiation of this plan.

4. An unpredicted and intense rainstorm struck one treatment plot (South Deep Creek) approximately 6 hours after spray application. An observer on the plot reported the storm arrived at 1605, rained hard for 10 minutes, rained steady for 25 minutes and lightly for 10 minutes.

5. One exceptionally favorable spray day occurred when weather conditions were apparently suitable for spraying until noon, and two adjacent blocks were treated on the same day. However, the second block treated was Benton Meadows. Spray deposit data and budworm mortality data indicate inadequate spray deposits in this block.

The weather forecasting and monitoring plan was followed except for one important addition. Following the cancellation of the first day's spraying, the weatherman and his assistant began traveling to the scheduled spray plot several hours in advance of dawn. They then radioed existing conditions and advise to the project leader at 0200. The project leader awoke and dispatched the crews between 0230 and 0400 when conditions were favorable.

This mode of operation for weather monitoring was effective and provided the best information for conducting the spray test. However, this schedule imposed an extreme work overload on the weatherman and his

assistant which could not be maintained for more than several days without relief. Fortunately the spray test was finished before the limits of human endurance required a less exhaustive work schedule.

It is possible to conclude that the effectiveness of the Dylox treatment was in some degree reduced by the rainstorm which occurred a few hours after spray application on one of the 1 pound treatment plot (South Deep Creek). The average percent control obtained on the South Deep Creek plot was about 80 percent; where the control obtained on the other two 1 pound treatment plots was 90 and 96 percent. Of course there are numerous other possible factors involved but it is reasonable that washing of spray deposits from the foliage of the trees could result from rain and this could deminish the level of control obtained from the application.

SAFETY MONITORING (RESULTS)

Water Contamination - One objective of the water contamination study was to correlate Dylox content of water samples with Rhodamine B dye content of the samples. In general a good correlation between flourometric measurements (dye content analysis) and chemical analysis for Dylox content was not shown.

Possible reasons for this which come to mind are (1) dye content not constant in all helicopter loads, (2) photo chemical decay of the dye over time without a corresponding change in Dylox content and (3) dissociation of Dylox (highly water soluble) from the dye (dissolved in an oil) in the water medium of the streams.

Good data on water contamination were provided for two streams and a pond by laboratory analysis of water sample for Dylox content.* These data are presented in Table XIII. The highest concentration measured was 1250 parts per billion (ppb) on South Deep Creek. This stream was purposely overflown paralled with the stream with the 1 pound per acre application to measure the maximum probable level of contamination and sampling station 1 was situation directly under the overflight. Down stream 1/2 mile, at station 2, the highest level measured was 61 parts per billion. Dylox levels in the Fandango plot stream were much lower - 16 and 25 ppb maximum. The application in that plot was 3/4 lb per acre and the stream was protected by a buffer strip; however it is known this unsprayed buffer strip was violated several times and some spray was applied to the stream as shown in Table XIV.

*Information provided by Dr. Richard Roberts, I.E.P.

- The objective of the water contamination study was to

Dylox content of water samples with Rhodamine B dye content of the

In general a good correlation between flourometric measurement

analysis) and chemical analysis for Dylox content was not shown

ome to mind are (1) dye content not

constant in all helicopter loads, (2) photo chemical decay of the dye

over time without a corresponding change in Dylox content and (3) dissociation

of Dylox (highly water soluble) from the dye (dissolved in oil) in the

water medium of the streams.

Good data on water contamination were provided for two streams and pond

y laboratory analysis of water sample for Dylox content. These data

are presented in Table XIII. The highest concentration measured was 1290

parts per billion (ppb) on South Deer Creek. This stream was purposely

[illegible] paralled with the stream with the 1 pound per acre application

[illegible] the maximum probable level of contamination and sampling

as situation directly under the overflight. Down stream 1/2

at station 2, the highest level measured was 61 parts per billion.

levels in the Fandango plot stream were much lower. 17 and 25 ppb

application in that plot was 3/4 lb per ac and the stream

buffer strip, however it is known this unsprayed buffer

times and some spray was applied to the stream

Table XIII

Residues of Dylox from various water sources after spraying for control of Modoc Budworm, Summer, 1974, Modoc County, California.

Source of Water	Time after spraying			Source of water	Time after spraying		
	Hrs.	Min.	ppb		Hrs.	Min.	ppb
Mill Creek Pond	Prespray		0	Fandango #1	Prespray		0
	0	30	24		0	30	16
	6	3	tr		7	0	7.8
	31	33	0.57		24	28	2.6
	75	38	tr		52	38	0.93
	174	28	0		76	13	0.82
	337	53	0		101	43	0.90
South Deep Creek #1	Prespray		0	Fandango #2	Prespray		0
	0	2	320		0	30	25
	0	15	1,250		7	25	6.7
	0	52	380		24	43	0.23
	7	37	67		53	48	0.38
	32	57	18.2		76	43	1.4
	51	27	22		102	29	1.05
	78	17	4.2				
	78	52	2.7				
	98	22	2.4				
South Deep Creek #2	Prespray		0	Fandango #3	Prespray		0
	0	42	22.2		1	20	2.5
	7	47	61		7	45	7.3
	32	47	9.2		25	3	0.26
	51	12	4.6		54	13	0.90
	98	42	0.64		77	8	1.32
					102	42	0.42

Mill Creek Pond and Fandango 1, 2, and 3, 0.75 lb/gal/acre.

South Deep Creek 1 and 2, 1.0 lb/gal/acre.

Table XIV

Contaminating Deposits Shown by Spot Cards Along the Stream Course in the Fandango and South Deept Creek Plots.

Site No.*	Spot Card Estimates (gal/ac)	
	Fandango	South Deep Creek
1	0.01	0.17
2	0.01	0.32
3	0.01	0.92
4	0.03	1.27
5	0.04	2.02
6	0.02	1.75
7	0.02	2.02
8	0.06	0.62
9	0.02	2.00
10	0.02	--
11	0.01	--
12	0.05	--
13	0.05	--
14	0.00	--
Av.	0.02	1.23

*Site numbers do not correspond with water sampling stations.

Fish* The effect on the fishery resource of the operational use of Dylox was evaluated according to plan.

(1) Monitoring Plan. The monitoring plan called for two test streams and one control stream. One proposed test area was to be treated with 3/4 lb/acre of Dylox and 100 foot buffer strips were to be maintained around all water. The second proposed test area was to be sprayed with 1 pound per acre of Dylox and no effort was to be made to avoid spraying water courses.

Forest Service biologists located six potential test streams in six different spray areas. Department of Fish and Game personnel determined the suitability of each potential test stream by electroshocking the fish population and examining the physical characteristics of each stream. The final selection of three test stream was based on the needs of the Forest Service to spray each area at a specific time when the budworm larvae were well developed, but before the larvae started to pupate.

Three sampling stations were established on each test stream. Two stations were located within the spray area dn one station was located one-half mile below the downstream boundary of the treated area. Control streams had only two stations. Each sampling station consisted of a live car holding 10 fish which had been captured from the same stream.

Each sampling station was established in the test streams at least a week before treatment of the area. Observations of the fish in the test area were made 24 hours and 1 hour prior to treatment and then 1 hour, 3 hours

*Prepared by T. C. Curtis, Pesticides Investigation Project, Federal Aid in Fish and Wildlife Restoration Project, FW1-R, August 1975.

24 hours, 48 hours, and 168 hours (1 week) post treatment. Fish were collected from each stream for residue analysis prior to treatment and again at 24 hours, 48 hours and 168 hours post treatment.

Observations of fish were recorded by the Department of Fish and Game fishery biologists and chemical residue analyses were provided by the Department of Fish and Game Pesticide Project chemists.

(2) Observations. Of the six creeks which were surveyed only two had populations of fish in areas which were to be sprayed. All streams had populations of trout downstream from the study area at lower elevations. The limiting factors appeared to be stream gradient and stream flow. The elevation of the streams varied from 6,200 to 7.200 feet.

Buck Creek, Joseph Creek, North Deep Creek and South Deep Creek were selected as test areas. Joseph Creek was the only one of the four to have an established population of fish. Joseph Creek and North Deep Creek were control streams, while the Buck Creek area was treated with Dylox at 3/4 lb/acre with 100 foot buffer strips maintained around the water, and the South Deep Creek area was treated at 1.0 lb/acre with no special attention to water courses. In addition, a live car station was placed in a pond along Mill Creek to test the survival of fish in static water which had been sprayed with Dylox at 3/4 lb/acre.

Rainbow trout (3-6 inches in length) were captured from the lower elevations of each stream and placed in the live cars at each station in those sections to be treated. Survival of the fish in the live cars during the pre-test holding period was excellent.

and 88 hours (1 week) post treatment.

[illegible] s for residue analysis prior to treatment and again at 24 hours, 48 hours and 168 hours post treatment.

[illegible] of fish were recorded by the Department of Fish and [illegible] sts and chemical residue analyses were provided by the Department of Fish and Game Pesticide Project chemists.

(7) Observations. Of the six creeks which were surveyed only two had populations of fish in areas which were to be sprayed. All streams had populations of trout downstream from the study area at lower elevations. The limiting factors appeared to be steep gradient and stream flow. The elevation of the streams varied from 6,200 to 7,900 feet.

[illegible] uck Creek, Joseph Creek, North Deep Creek and South Deep Creek were selected as test areas. Joseph Creek was the only one of the four to have an established population of fish. Joseph Creek and North Deep Creek were control streams, while the Duck Creek area was treated with Dylox at 3/4 lb/acre with 100 foot buffer strips maintained around the water, and the South Deep Creek area was treated at 1 lb/acre with no special attention to water courses. In addition a live car of fish [illegible] s placed in a pond along Mill Creek to test [illegible] 1 of fish in a stream [illegible] which had been sprayed with Dylox at 3/4 lb/acre.

[illegible] ed from the [illegible]

[illegible] each station

[illegible] in the live cars

(Buck Creek) The Buck Creek test section was located between 6,200 to 6,600 feet in elevation with a stream gradient of 800 feet per mile. Stream temperature varied between 56-56 degrees F. There was an overstory of mature timber over 80 percent of the test section. On the site observations of the treatment indicated that the helicopter application was successful at maintaining a buffer strip around the stream. Observation of the live car fish following the application of Dylox showed no indications of stress. No mortalities occurred in the live cars.

(South Deep Creek) The test section on South Deep Creek varied between 6,900 to 7,200 feet in elevation with a stream gradient of approximately 350 feet per mile.

Temperatures in the stream varied from 46 to 58 degrees F. Thirty percent of the stream had a timber overstory. The stream was not well channelized in the upper end of the test area. The helicopters applying the material flew directly up the stream completely covering the stream with spray droplets. Observing the stream after the spray, numerous small slicks of oil were apparent on most pool and eddy areas. The fish in the live cars showed no signs of stress at any time during the test period.

(North Deep Creek) The stations on North Deep Creek were located at 7.100 and 6,900 feet where the stream gradient was 400 feet per mile. This area was to serve as a control for South Deep Creek, but the headwaters of North Deep Creek were mistakenly sprayed when South Deep Creek was treated. Despite the spray no stress or mortality was observed among the test fish in the live cars.

(Joseph Creek). The second control was Joseph Creek which was the only stream with a resident population of fish. The stations were located at 6,400 and 6,500 feet in elevation where the stream gradient was approximately 400 feet per mile and the upper limit of water temperature was 60 degrees F. No mortality or stress was observed among the test fish during their confinement in the live cars.

(Mill Creek). A live car station was established on a beaver pond on Mill Creek for a static water evaluation. None of the fish died after the pond was sprayed with Dylox at the 3/4 lb/acre rate.

(3) Residues. Fish were taken from the live cars on each test stream prior to the test and at 24, 48, and 168 hours post treatment. The samples were wrapped in aluminum foil and frozen until they were prepared for chemical analysis. Several individuald fish from each live car were composited and ground in a blender. The homogenized sample was extracted and the extract analyzed by gas chromatography for Dylox residue.

No detectable residues of Dylox were found in any of the fish. The sensitivity of the analyses was 0.5 ppm (parts per million) in the sample.

Aquatic and Terrestrial Insects* The investigation was designed to monitor the effects of spray on insects in stream zones by sampling a sprayed stream (South Deep Creek), a stream protected with a buffer zone (Fandango) and a totally unsprayed stream (North Deep Creek). Unfortunately the unsprayed check stream (North Deep Creek) was overflown several times. Spray deposits, as indicated on spot cards, were reported

*Information reported by Henry W. Newhouse, Fisheries Biologist, Modoc Natural Forests who planned and conducted the study.

[illegible] Creek). The second control was [illegible] Creek which was the only stream with a resident population of fish. The stations were located at 6,400 - 6,500 feet in elevation where the stream gradient was approximately 400 feet per mile and the upper limit of water temperature [illegible] degrees F. No mortality or stress was observed among the [illegible] fish after their confinement in the live cars.

(Mill Creek). A live car station was established on a beaver pond on Mill Creek for a static water evaluation. None of the fish died after the pond was sprayed with Dylox at the 3/4 lb/acre rate.

(3) Residues. Fish were taken from the live cars on each test stream prior to the test and at 24, 48, and 168 hours post treatment. The samples were wrapped in aluminum foil and frozen until they were prepared for chemical analysis. Several individual fish from each live car were composited and ground in a blender. The homogenized sample was extracted and the extract analyzed by gas chromatography for Dylox residue.

No detectable residues of Dylox were found in any of the fish. The sensitivity of the analyses was 0.5 ppm (parts per million) in the sample.

[illegible] The investigation was [illegible]

[illegible] on insects in stream [illegible] by sampling [illegible]

[illegible] Creek), a stream [illegible] with a [illegible]

[illegible] sprayed [illegible]

in Table XIII for the first two streams. This information for the check stream (North Deep Creek) was 1.34, 0.00, 0.10 and 0.06 gallons per acre at 4 locations along the stream.

The study plan was carried out except the live box component was unsuccessful and found to be unsuitable for field application. Bethic samples were relatively constant during each sampling period in all the monitored streams. This indicates that the Dylox treatment did not eliminate any of the aquatic insect communities. Drift samples showed very little effect of the treatment at Fandango or North Deep Creek. At South Deep Creek, however, there was a dramatic increase in the number of Trichoptera in the drift 4 to 6 hours after spraying and a notable increase in Ephemeroptera 26 to 30 hours after spraying. The Dylox had a unexpected negligible effect on aquatic Diptera and terrestrial insects of the stream zone.

2 two streams. This information for the [illegible]

was 1.34, 0.1[illegible], 0.10 and 0.05 ug/liter per gram

[illegible]

out except the live box component [illegible]

[illegible] to be unsuitable for field application. Benthic

samples [illegible] relatively constant during each sampling period in all

the monitored streams. This indicates that the Dylox treatment did not

eliminate any of the aquatic insect communities. Drift samples showed

very little effect of the treatment at Fandango or North Dog Creek.

At South Dog Creek, however, there was a dramatic increase in the

number of Trichoptera in the drift 4 to 6 hours after spraying and a

notable increase in Ephemeroptera 26 to 30 hours after spraying. The

Dylox had a unexpected negligible effect on aquatic Diptera and

terrestrial insects of the stream zone.

Wildlife* Data regarding the effects of Dylox on avion wildlife were collected on survey transects according to plan. However no birds were actually collected for tissue analysis as none were found dead or in a distressed condition. During the monitoring program, 10 active nests, representing 8 species of birds, were found enabling the investigation to be expanded to include nesting data.

On pre-spray transects, 184 birds were counted and 35 species were identified. The numbers of birds observed increased and all species, except one (MacGillivray's Warbler), again were identified in one or both of the post-spray transects (Table XV).

*Information provided by E. Leon Fisher, Forest Wildlife Biologist, Modoc National Forest, who designed and conducted the investigation.

[illegible] collected for tissue analysis as none were found dead or in a distressed condition. During the monitoring program, [illegible] nests, representing [illegible] species of birds, were found and [illegible] investigation to be expanded to include nesting data.

In pre-spray transects, 194 birds were counted and [illegible] species were [illegible] the numbers of birds observed increased and all species, except the MacGillivray's Warbler), again were identified in one or both of the post-spray transects (Table XV).

[1] Information provided by E. Leon Fisher, Forest Wildlife Biologist, Modoc National Forest, who designed and conducted the investigation.

Table XV. Bird Censes Before and After Treatment[1]

Time of Transects	Number of Birds Observed
Pre-treatment	184
48-Hour Post-treatment	272
7-Day Post-treatment	224
TOTAL	680

[1] 1 lb AI per acre

During the 48-hour post-spray transects, large numbers of budworm larvae were seen suspended from webs in the canopy zone of the forests, ostensibly in response to the effects of the spray. (Photo 27) The increase in bird numbers following spraying was apparently related to the increased exposure (availability) of this food source.

Undoubtably birds within the treated area accumulated Dylox into their system by contact and ingestion of contaminated food and water. During post-spray transects and subsequent next observations, not one bird observed exhibited any characteristics which could be classed as unusual or abnormal. Neither were any dead or dying birds found.

[illegible]

TOTAL

[1] 1 lb AI per acre

During the 48-hour post-spray censuses, lower numbers [illegible] were observed [illegible] seen subtended from nests in the canopy zone of the [illegible] [illegible] [illegible] to the effects of the spray. (Photo 27) The increase in bird [illegible] following spraying was apparently related to the increased exposure [illegible] of this food source.

[illegible] birds within the treated area accumulated Dylox into their [illegible] contact and ingestion of contaminated food and [illegible] [illegible] transects and subsequent nest observations, none of the birds [illegible] exhibited any characteristics which could be classed as [illegible] [illegible]. Neither were any dead or dying birds found.

Photo 27. Large accumulation of [illegible] formed by Dylox effected larvae.

BUDWORM PARASITES*

The parasitoid complex was successfully identified and relative numbers determined. The complex associated with the Modoc budworm does not seem to be excessively rich in represented species or total numbers.

The parasitoid complex was composed primarily of 3 species, tentatively identified as Apanteles sp. (Hymenoptera: Braconidae), and Glypta sp. (Hymenoptera: Ichneumonidae), and a Tachinid sp. (Diptera). At least two other species of parasitoids were found in low numbers, but these species were too rare to monitor using the existing sampling schemes. Specimens of the parasitoid complex have been submitted to toxonomists at the California Department of Food and Agriculture for authoritative determinations.

The biology of these parasitoids appears similar to parasitoids of the same genus on a closely related host, Choristoneura occidentalis, the western spruce budworm. The adult parasitoid lays its eggs on the 1st-2nd instar host larva in the fall. The parasitoid egg hatches and the parasitoid larva burrows into the host larva. Both host and parasitoid larvae overwinter, and resume feeding in the spring. As the host larva approaches the 4th-6th instar, the fully-developed parasitoid larva emerges from its host, and spins a cocoon on the foliage. The adult emergence occurs in late June or early July.

---

* Information provided by Fay Shon, Entomologist, R-5, FPC, who designed and carried out the study.

To monitor the parasitoid populations, larval budworm from population samples were removed from branches and reared in groups of about 10 in. petri dishes. (Photo 19). Artificial media was provided for food. As the parasitoid larvae emerged from the host larvae to pupate, the parasitoid cocoons were removed and placed in clean petri dishes until the adult parasitoid emerged. The adult parasitoid was identified and the data recorded. If no parasitoid emerged from the host (budworm) larvae, the host was reared to the adult stage and discarded.

Population counts on three species of parasitoids are given in Table XVI. The counts are expressed in the percent of the host population parasitized by each of the parasitoid species, and by all of the species together. The results indicate that there was no significant change in the parasitoid population when comparing the treatment plots with the check plots. Some of the change in the percent of the host population parasitized by any particular species was caused because the onset of sampling coincided with the peak dates for parasite emergence, (prespray sampling), and continued as parasite emergence declined, (6 and 16 day post spray samples). However, the same phenomenon occurred simultaneously in the check plots, accounting for the decline in percent parasitization in untreated areas. While there appears to be an increase in parasitization during the 6-day post sample--particularly in the 1 pound treatment--the error terms are too large for the data to really reflect this. Later in the 16-day post sample, the percent parasitization figures change to reflect the original condition.

[illegible] ed from branches and reared in groups of [illegible] petri dishes (Table 19). Artificial media [illegible] for host [illegible]. As the parasitoid larvae emerged from the host larvae [illegible], the parasitoid cocoons were removed and placed in [illegible] petri dishes until the [illegible] parasitoid emerged. The adult parasitoid was then [illegible] as [illegible]. If no parasitoid emerged from the host [illegible] larvae, the host was reared to the adult stage [illegible] discarded.

Population counts on three species of parasitoids [illegible] given [illegible]. The counts are expressed in the percent of the host population [illegible] by each of the parasitoid species, and by all of the species [illegible]. The results indicate that there was no significant change in [illegible] parasitic population when comparing the treatment plots with the [illegible]. Some of the change in the percent of the host population parasitized by any particular species was caused because the [illegible] set of sampling [illegible] with the [illegible] dates for parasite emergence [illegible] continued as parasite emergence declined [illegible] samples). However, the same phenomenon occurred [illegible] in the [illegible] plots, accounting for the decline in [illegible] parasitization in [illegible]. While there appears to be [illegible] [illegible] data to really reflect this [illegible] percent parasitization figures change [illegible]

The numbers in Table XVI indicate a change in the relative proportions of the species comprising the population. However, these changes also reflect differences in emergence times. At the onset of population sampling, (prespray), Apanteles sp. was at its peak emergence and appears to be the major species in the complex. By the 6-day postspray sample, the most abundant parasitoid species has shifted to Glypta sp., which was then at its peak emergence. The Tachinid species was always the smallest component of the complex. It was most numerous in the prespray sample, but declined to 0 in the 16-day postspray samples.

Field and laboratory work done in 1975 served to document the fact that the parasite complex was still viable in treated areas. Due to the reduced sampling program in 1975, an aggregate of all samples is needed for analysis and the results are not directly comparable to the earlier results.

TABLE XVI. <u>PERCENT OF HOST POPULATION PARASITIZED BY EACH OF 3 MAJOR PARASITOID SPECIES AND BY ALL PARASITOID SPECIES (WITH SAMPLING ERROR TERM)</u>

Time and Treatment (1)	*Apanteles* sp.	*Glypta* sp.	Tachinid	Total Parasi[illegible]
Pre-spray				
1 pound	5.6 ± 2.8	3.1 ± 2.0	0.9 ± 0.6	10.0 ± 4.[illegible]
3/4 pound	5.7 ± 2.2	4.0 ± 2.0	1.0 ± 1.4	10.7 ± 3.[illegible]
Zero	6.8 ± 4.0	2.6 ± 1.0	2.7 ± 1.6	12.4 ± 4.[illegible]
6-day post-spray				
1 pound	8.7 ± 12.6	12.5 ± 1.2	0.0	21.2 ± 16.[illegible]
3/4 pound	5.6 ± 3.4	3.7 ± 2.8	1.67 ± 1.8	11.0 ± 5.[illegible]
Zero	1.2 ± 1.2	1.2 ± 1.4	0.8 ± 1.0	5.2 ± 3.[illegible]
16-day post-spray				
1 pound	2.4 ± 5.0	1.6 ± 3.3	0.0	4.5 ± 5.[illegible]
3/4 pound	4.6 ± 5.5	4.0 ± 0.4	0.0	7.9 ± 6.[illegible]
Zero	4.9 ± 5.2	0.3 ± 0.6	0.0	7.9 ± 6.[illegible]
1975 (2)				
1 pound	4.3 ± 19.0	1.4 ± 17.8	0.0	5.7 ±
3/4 pound	10.3 ± 85.6	0.0	0.0	10.3 ± 85.[illegible]
Zero	7.2 ± 17.2	0.5 ± 1.3	1.8 ± 22.7	8.4 ± 3.[illegible]

(1) Dylox (AI) per acre

(2) Composit sample for all of 1975. Due to differences in sample size and different timing in 1975, these figures are not directly comparable to those from the prior periods.

NON-TARGET TERRESTRIAL ARTHROPODS*

The survey of the effects of Dylox on non-target terrestrial arthropods was conducted as planned, resulting in the collection of some 1800 branch and 180 litter samples. Adequate funds have not been available to properly extract all of the information latent in the survey; however, a summary for important groups is shown in Table XVII. While the intent of the survey was to show effects of spraying as non-target arthropods, the Modoc budworm was a prominent component of the samples and recorded data for the budworm is also summarized here for comparative purposes.

---

* Information reported by Dr. E.I. Schlinger, U.C., who planned and conducted the survey.

TABLE XVII. EFFECTS OF DYLOX SPRAY ON TERRESTRIAL ARTHROPODS

Organism Treatment (2)	Populations (1)			Population Change Percent	
	Pre-Spray	Post-Spray			
		6-Day	16-Day	6-Day	16-Day
Ants					
1 pound	0.45	0.24	0.04	-47	-91
3/4 pound	0.62	0.78	0.14	+26	-77
0 pound	0.37	0.15	0.16	-56	-56
Spiders					
1 pound	1.00	0.70	0.51	-30	-49
3/4 pound	1.20	0.66	0.90	-45	-25
0 pound	0.88	0.99	0.78	+12	-12
Parasites					
1 pound	0.46	0.66	0.43	+44	-6
3/4 pound	0.38	0.45	0.70	+18	+84
0 pound	0.27	0.34	0.23	+26	-14
Modoc Budworm					
1 pound	3.17	1.48	0.66	-53	-79
3/4 pound	4.12	1.35	0.93	-67	-77
0 pound	3.53	2.07	1.55	-41	-56

(1) Specimens per branch (mean)

(2) Dylox (AI) per acre

RESIDUE ANALYSIS*

Samples for residue analysis of Dylox deposits on selected vegetation and water were collected and analysed as planned. The results of the investigation concerned with water were reported under Water Contamination and Table XIII of that section. The results of the analysis of vegetation samples are reported in Table XVIII below:

TABLE XVIII. RESIDUES OF DYLOX FROM FOLIAGE SPRAYED FOR CONTROL OF MODOC BUDWORM, SUMMER, 1974, MODOC COUNTY, CALIFORNIA (1.0 lb./gal./acre)

Plot	Foliage Type	Time in days after spraying				
		0	1	7	14	28
		Residue (ppm)				
Manzanita	Mt. Mahogany	12.9	15.5	3.11	0.54	1.02
	Snowberry	77.2	87.0	2.84	1.62	0.69
	White Fir	17.04	12.5	1.42	Trace	Not Sampled
South Deep Creek	Mt. Mahogany	5.4	5.42	2.83	0.073	0.596
	Snowberry	81.5	4.86	1.76	0.244	0.092
	White Fir	0.492	0.60	0.42	0.043	Not Sampled
Long Valley	Mt. Mahogany	30.4	16.0	0.83	1.39	0.46
	Snowberry	83.5	37.9	2.56	0.46	0.30
	White Fir	11.6	14.8	0.022	0.091	Not Sampled

* Information reported by Dr. Richard Roberts, IEP

DISCUSSION

TEST DESIGN

The use of large plots in this pilot control project permitted a demonstration of the practical use of the control method to be made. This includes the demonstration of the effects of errors or calamities which are likely to befall a large scale operation; in this case a poor application on one plot and a rainstorm on another plot. Large plots also mitigate against reinvasion of the test area by insects from outside, enabling a longer term evaluation of the effects of treatments to be made.

The omission of a treatment to test the effect of the carrier solution on insect mortality is more of academic rather than practical interest. The problem is the tardy realization that oleic acid has insecticidal properties but the amount of oleic acid used and its insecticidal effects are small.

DEVELOPMENTAL SAMPLING

The importance of timing of spray application is shown by the differential effects of the treatment on the various insects monitored during the project. The Modoc budworm was suppressed by the spray treatments but the spruce cone worm was reduced in one area but not in others and the white fir needle miner apparently was not effected at all. The difficulty of contacting millions of insects with short residual insecticides applied over a tree crown canopy a hundred or more feet thick requires that the target pest be in its most exposed and active stage; hidden or inactive insects or stages frequently escape contacting the spray.

use of large plots in this

demonstration of the practical

This includes the demonstration

which are likely to be

on one plot and

also mitigate against

outside, enabling a longer

to be made.

omission of a treatment to test the effect

on insect mortality is more of academic

The problem is the tardy realization that oleic acid

but the amount of oleic acid used and its insecticidal effects

ELEMENTAL SAMPLING

The importance of timing of spray application is shown by

effects of the treatment on the various insects

The Modoc budworm was suppressed by the spray treatments

spruce cone worm was reduced in one area but not in others

fir needle miner apparently was not affected at all. The

contacting millions of insects with short residual

a tree crown

most exposed and

frequently escape contacting

Prior to the Pilot Control Project, the biology and development of the Modoc budworm was not well known and there was no assurance that the most susceptible stage could be recognized and treated. However, the results indicate that correct timing can be determined for spraying over large areas.

PRE- AND POST-SPRAY SAMPLING

Pre- and post-spray sampling is the main way of showing the effectiveness of the spray treatments. The results indicate that an acceptable level of control was achieved with the 1 pound of Dylox per acre treatment and a nearly acceptable level of control was obtained with the 3/4 pound per acre treatment. It is important to point out that in calculating these results the negative effects of a poor application (Benton Meadows) or a rainstorm (South Deep Creek) were not deleted form the data. If a good application were assured, effective control could probably be obtained with the 3/4 pound treatment.

Determining that the treatments were effective need not depend only on the fact that a large percentage of the target pest population was killed. Low budworm numbers in the egg stage and subsequent larval stage, one year after spraying, in treated plots were also demonstrated. Egg mass numbers less than ten and larvae numbers less than 30 per 1000 sq. in. of foliage are considered acceptable.

DROP CLOTHS

The drop cloth experiment provided an independent check on the effectiveness of Dylox against the target pest and related insects.

wasn't well known and there was no assurance that the susceptible stage would be recognized and treated. However, the results indicate that correct timing can be determined for spraying over large areas.

PRE- AND POST-SPRAY SAMPLING

Pre- and post-spray sampling is the main way of assessing the effectiveness of the spray treatments. The results indicate that an acceptable level of control was achieved with the 1 pound of Dylox per acre treatment and a nearly acceptable level of control was obtained with the 3/4 pound per acre treatment. It is important to point out that in calculating these results the negative effects of a poor application (Benton Meadows) or a mistake (Swift Leap Creek) were not deleted from the data. If good application were assured, effective control could probably be obtained with the 3/4 pound treatment.

Determining that the treatments were effective need not depend only on the fact that a large percentage of the pest population was killed.

Low budworm numbers in the

year after spray ... in trea

numbers less than ten

of foliage

Indications of successful suppression of the budworm was obtained and it appears that the period of effectiveness extends for 4 to 6 days. Dylox seems to have a variable effect on the other insect inhabitants of the forest, being quite deadly for flies, intermediately hazardous to beetles and less hazardous to ants. However, for unknown reasons, it appears that the 3/4 pound treatment was most destructive to all considered insects except the Modoc budworm. This effect, if real and not an artifact of sampling, seems strongest for spruce coneworm, scarab beetles and ants.

SPRAY CARDS AND PLATES

To much time and effort was devoted to deploying and analysing spray cards and plates, considering the quantity and quality of information derived by this effort. However, part of this investment was devoted to improving the techniques and future spray projects should benefit from this experience.

ESTIMATES OF FOLIAGE CONSERVATION

The Pilot Control Project determined that generally the spray application did not save an obvious amount of foliage on spray plots. This verified the reasonable expectation that a control technique applied to suppress late instar larvar of a defoliating insect has little opportunity to curtail the feeding of the treated generation of larvae. Benefits of spraying, under these circumstances, are mainly directed to preventing damage by the following generation. This is a considerably different situation than exists in suppressing some other defoliators, such as the Douglas-fir tussock moth, where the most effective timing for spraying

is the early instars and there is a good likelihood of reducing current defoliation.

The methods of estimating foliage conservation used in this project are not satisfactory for measuring small differences in defoliation intensity. They tend to be too subjective to be consistently applied by many field workers.

WEATHER FORECASTING AND MONITORING

Weather forecasting and monitoring were indespensible tools which on more than one occasion prevented spraying under unsuitable conditions. The possible negative effect on spray deposits caused by rain and late spraying simply points out that good weather services are not infallible in guaranteeing successful application. The poor spray deposits obtained on Benton Meadows cautions against extending spray applications late into the morning hours even when wind and temperature conditions appear favorable.

SAFETY MONITORING

The aquatic environs, as monitored by the effects on fish and insects, was not greatly effected. In the case of an intentional overdose applied to one stream, an increase in the drift sample of two kinds of aquatic insects occurred, but this did not happen in normally sprayed areas.

No detectable effects was found on warm blooded animals, as monitored by effects on birds, even though the birds ate large numbers of the poisoned budworm larvae.

Spray residues persisted longer than expected, in small amounts, on some kinds of vegetation.

The study of Modoc budworm parasites indicates the spraying did not greatly alter the host-parasite ratio. The survey of associated arthropods show no serious disruptions but there are suggestions of effects and relationships which should be further analysed and explained.

For example the large decline in ants 16 days after spray could be due to the fact that most of the ant food--budworm and coneworm larvae--was gone and the ants were foraging elsewhere. Similarly the apparent increase in parasites, in the 3/4 pound treatment plots 16 days post-spray, may be an interesting lead to investigate.

In summary, no serious derangement of the biological environment by the spray applications was detected by safety monitoring activities. No acute toxicity to fish or birds occurred. No damage to nesting birds was observed. No sub-acute toxicity to fish seems likely since residues in fish were absence or were less that detectable amounts (sensitivity 0.5ppm). Cholinesterose inhibition in birds (sub-acute toxicity) was not checked in this pilot control project. However, cholinesterose depression of birds was studied on plots treated with 1 pound of Dylox per acre in Montana. No serious adverse effects on birds were found (Graham 1975). Post-spray residues are non-persistent. Residues in water occurred only in parts per billion quantities and residues on vegetation were in all cases less than 90 parts per million.

RECOMMENDATION

1. Pursue registration of Dylox for Modoc budworm control by providing foregoing efficacy and safety information to the insecticide manufacturer, Chemagro Corporation.

2. Continue the investigation of the growth impact caused by the defoliation of white fir by the Modoc budworm.

3. Monitor future trends of the Modoc budworm infestation by a reduced sampling of budworm larvae and eggs until populations return to endemic levels.

Bibliography

1. Andrews, Theresa L. and Raymond P. Miskus. 1972. Some effects of fatty acids and oils on western spruce budworm larvae and pupae. Pesticide Biochemistry and Physiology (2): 257-261. October 1972.

2. Andrews, W. Earlston and Phillis A. Dugar. 1972. Background document for Dylox insecticide. USDA, Forest Service, Wash. D.C.

3. Anon. 1971. Dylox insecticide. Chemagro Corp., Kansas City, Mo. January 1971.

4. Anon. 1973. Cooperative 1973 gypsy moth suppression and regulation program. USDA Environmental Impact Statement. USDA Forest Service and APHIS, Wash. D.C. March 28, 1973.

5. Bousfield, Wayne E. 1974. Sampling the target insect. Proceedings Aerial Applications of Insecticides Against Forest Defoliators (Chemicals and Microbiols). April 23-24, 1974. USDA Forest Service Northern Region, Missoula, Montana.

6. Graham, David A. 1975. Western spruce budworm insecticide test results. Presented by D.A. Graham, Director, Insect and Disease Management, US Forest Service, Portland, Oregon to the Western Forest Pest Committee, Western Forestry and Conservation Association at Vancouver, B.C. on December 3, 1975.

7. Graham, Kenneth 1963. Concepts of forest entomology. Reinhold Publishing Corp., New York, Pg. 176-181.

8. Pierce, John R. 1974. Environmental analysis report: pilot test program, Modoc budworm. USDA Forest Service, San Francisco California, March 6, 1974.

9. Pierce, John R., Max Olllieu and Fay Shon. 1974. A biological evaluation: budworm outbreaks on the Modoc National Forest in 1973. USDA Forest Service, San Francisco, Ca. March 1974.

10. Robertson, Jacqueline L. 1974. Summary of toxicity of 12 insecticides. Feb. 4, 1974. USDA Forest Service, Berkeley, Ca. (IEP memorandum).

11. Swain, Kenneth, 1974. Environmental analysis report: pilot test program. Modoc budworm. USDA Forest Service, San Francisco, Ca. June 17, 1974.

12. Swain, Kenneth M., John R. Pierce and Max M. Ollieu. 1974. Pilot test plans of Dylox on the Modoc budworm. USDA Forest Service San Francisco, Ca. June 17, 1974.

Bibliography

Anderson, Thomas [illegible] and Raymond E. Nishiura. 1971. Some aspects of [illegible] acids and oils of western spruce budworm larvae and pupae. [illegible] Biochemistry and Physiology (2): 357-361. October 1972

Andrews, W. Carlston and Phyllis A. Dugan. 1976. Background document for Dylox insecticide. USDA, Forest Service, [illegible]

Anon. 1961. Dylox insecticide. Chemagro Corp., Kansas City, Mo. January 1971

Anon. 1973. [illegible] 1973 gypsy moth suppression and regulation program. USDA Environmental Impact Statement. USDA Forest Service [illegible] Wash. D.C. March 28, 1973.

Bousfield, Wayne E. 1974. Spraying the forest insect. Proceedings [illegible] annual [illegible] Society of American Foresters [illegible], April 23-24, 1974. USDA Forest Service Northern Region, Missoula, Montana.

Brown, Ronald A. 1975. Western spruce budworm insecticide test results. Presented by [illegible], Director, Insect and Disease Management, US Forest Service, Portland, Oregon to the Western Forest Pest Committee, Western Forestry and Conservation Association at Vancouver, B.C. on December 1, 1975.

Graham, Samuel [illegible] 1952. Concepts of forest entomology. [illegible] Corp., New York. pp. 175-181.

[illegible], John R. 1974. Environmental analysis report [illegible] test program, Modoc [illegible]. USDA Forest Service, San Francisco, California. March 6, 1974.

Hopkins, John S., [illegible] Dillon and Roy Shon. 1974. A biological evaluation of budworm outbreaks on the Modoc National Forest in 1973. USDA Forest Service, San Francisco, Ca. March 1974.

[illegible] Caroline L. 1974. Summary of toxicity of [illegible] Feb. 7, 1974. USDA Forest Service, Berkeley [illegible] (Unpublished).

[illegible] 1974. Environmental analysis report [illegible] pilot test [illegible]. USDA Forest Service, San Francisco, Ca. [illegible] 1974.

[illegible], [illegible] R., [illegible] R. Rivers and [illegible] H. Dillon. 1974. [illegible] of Dylox on the Modoc budworm. USDA Forest Service San Francisco, Ca. June 12, 1974.

13. Williams, Carroll B. Jr. 1974. Pilot test of Zectran on _Choristoneura_ populations in Modoc National Forest. U.S.D.A. Forest Service, Berkeley, Ca. April 30, 1974 (IEP-Draft Study Plan).